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ABSTRACT

Teacher knowledge and skills are critical elements in the student learning process. Action research serves as an increasingly popular technique to engage teachers in educational change in classrooms. This document focuses on action research reports of elementary school teachers. Chapters include: (1) "First Graders' Beliefs and Perceptions of 'What Is Science?' and 'Who Is a Scientist?'" (Laura G. Joanos); (2) "Implementing an Authentic Science Learning Experience" (Jennifer W. Yelverton); (3) "Changing a Teacher's Role To Evoke Meaningful Learning Behaviors" (Paul M. Veldman); (4) "Does Student Responsibility for Learning Increase When Students Ask and Answer Their Own Problem-Solving Questions?" (Toni B. Haydon); and (5) "So You Want To Do Action Research?" (Angelo Collins and Samuel A. Spiegel). Each chapter contains references. (YDS)

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Science *in the* Elementary School Classroom

Portraits of Action Research

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Science FEAT *Science For Early Adolescence Teachers*

Science *in the* Elementary School Classroom

Portraits of Action Research

edited by
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Penny J. Gilmer

with a Foreword by
Dr. Francena Cummings

1997

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This is dedicated in memory of

Victoria Hodge

a science educator and Science FEAT graduate who died of sickle-cell anemia in November 1995.

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About the SERVE Organization

SERVE, the SouthEastern Regional Vision for Education, is a consortium of educational organizations whose mission is to promote and support the continuous improvement of educational opportunities for all learners in the Southeast. Formed by a coalition of business leaders, governors, policymakers, and educators seeking systemic, lasting improvement in education, the organization is governed and guided by a Board of Directors that includes the chief state school officers, governors, and legislative representatives from Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina. Committed to creating a shared vision of the future of education in the Southeast, the consortium impacts educational change by addressing critical educational issues in the region, acting as a catalyst for positive change, and serving as a resource to individuals and groups striving for comprehensive school improvement.

SERVE's core component is a regional educational laboratory funded since 1990 by the Office of Educational Research and Improvement (OERI), U.S. Department of Education. Building from this core, SERVE has developed a system of programs and initiatives that provides a spectrum of resources, services, and products for responding effectively to national, regional, state, and local needs. SERVE is a dynamic force, transforming national education reform strategies into progressive policies and viable initiatives at all levels. SERVE Laboratory programs and key activities are centered around:

- Applying research and development related to improving teaching, learning, and organizational management
- Serving the educational needs of young children and their families more effectively
- Providing field and information services to promote and assist local implementation of research-based practices and programs
- Offering policy services, information, and assistance to decision makers concerned with developing progressive educational policy
- Connecting educators to a regional computerized communication system so that they may search for and share information, and network
- Developing and disseminating publications and products designed to give educators practical information and the latest research on common issues and problems

The Eisenhower Consortium for Mathematics and Science Education at SERVE is part of the national infrastructure for the improvement of mathematics and science education sponsored

by OERI. The consortium coordinates resources, disseminates exemplary instructional materials, and provides technical assistance for implementing teaching methods and assessment tools.

The SouthEast and Islands Regional Technology in Education Consortium (SEIR◆TEC) serves 14 states and territories. A seven-member partnership led by SERVE, the consortium offers a variety of services to foster the infusion of technology into K-12 classrooms. The Region IV Comprehensive Assistance Center provides a coordinated, comprehensive approach to technical assistance through its partnership with SERVE.

A set of special purpose institutes completes the system of SERVE resources. These institutes provide education stakeholders extended site-based access to high quality professional development programs, evaluation and assessment services, training and policy development to improve school safety, and subject area or project-specific planning and implementation assistance to support clients' school improvement goals.

Following the distributive approach to responding and providing services to its customers, SERVE has ten offices in the region. The North Carolina office at the University of North Carolina at Greensboro is headquarters for the Laboratory's executive services and operations. Policy offices are located in the departments of education in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina.

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Foreword

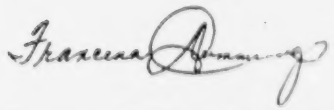
On the whole, the school reform movement has ignored the obvious: what teachers know and can do makes the crucial difference in what children learn.
(Linda Darling-Hammond, 1996)

The preceding quote from *What Matters Most: Teaching for America's Future* supports the premise that teacher knowledge and skills are critical factors in student learning. This should not be a surprise to the education community; however, to some extent, educational settings are often void of conditions that enable teachers to teach in ways that push the boundaries of traditions to link learning and teaching to meaningful situations. Moreover, conditions are void of high expectations for teachers to generate knowledge and understanding about their own work.

In recent years, action research has become one of the more increasingly popular and innovative techniques for engaging teachers in shaping change in the classroom. Throughout academia it is being endorsed as an effective means to change classroom practice. The National Science Teachers Association (NSTA) and the National Council of Teachers of Mathematics (NCTM) both acknowledge the role of "teacher as researcher" as an effective means to promote professional development and professionalism in teaching. Moreover, it serves as a bridge to link research and practice.

This second volume of Action Research *Science in the Elemenary School Clasroom: Portraits of Action Research* focuses on elementary teachers. While the first volume focused on middle school teachers, both report results that offer teachers opportunities to better understand their classroom contexts, their practices, and their students. Also, they offer practitioners the opportunity to use and value research by being "knowledge generators."

The Consortium is proud to support the development, publication, and dissemination of this valuable product. We value teachers and we offer this product as yet another tool that may be helpful in making a difference in teaching science. For what they know and are able to do make the most difference in what students learn.



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Elizabeth Viggiano, a Science FEAT program assistant and currently a science teacher at Raa Middle School, helped select and edit various versions of the papers. She also served as a mentor during the action research projects.

Angelo Collins, presently at Vanderbilt University, was a Co-Principal Investigator of Science FEAT while a faculty member in Curriculum and Instruction at Florida State University during the program. Dr. Collins had the vision of how teachers could utilize action research to transform their teaching and the learning of their students and helped in the final stages of the monograph by reviewing final versions of the papers.

Jim Lappert, currently a biology teacher at Leon High School and an editor for the first monograph from Science FEAT, helped in the planning stages of this monograph.

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We express our gratitude to the entire group of Science FEAT teachers, the administrators and other faculty members at the participant's schools, and the parents of the researchers' students.

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This is available in alternative format upon request.

Setting the Scene for Action Research

Penny J. Gilmer and Jane B. McDonald

"Who indeed can afford to ignore science today? At every turn we have to seek its aid. The future belongs to science and to those who make friends with science."
Jawaharlal Nehru.

The past few decades have seen tremendous ferment in the educational community. The Sputnik era of the 1960's exposed our nation as unable to compete globally in science and mathematics, and in 1983, *A Nation at Risk* (United States National Commission on Excellence in Education) called for considerable reform of the educational system. Nehru spoke eloquently of science and the future. President Bush made Nehru's statement applicable to our nation in his 1990 State of the Union address when he gave our schools the mission: "By the year 2000, U.S. students will be first in the world in science and mathematics achievement" (National Education Goals Panel, 1991, p.5). In reaction, professional associations have produced innovative curricula and evaluation and instructional standards to improve the quality of science education and move our country toward a scientifically literate society.

Some progress has been made. According to the *Science & Engineering Indicators—1996*, the general pattern for science achievement scores had been "one of decline or stagnation during the 1970's, followed by steady increase throughout the 1980's" but now "the 1992 average science scores are higher than in 1977 for 9- and 13-year-olds, but are lower for 17-year-olds" (National Science Board, 1996, p. 1.2; see table 2.1 of Campbell, et al., 1996, p. 53, for complete data). Also, initial findings of the Third International Mathematics & Science Study show that the standing of U.S. eighth graders in science is at or above the international average (Peak, 1996, p.68).

The reason, however, for the improvement is unclear. "No single factor can be considered to influence student performance in isolation from other factors" (Peak, 1996, p.68). The development of standards and curriculum and the active involvement of teacher educators and state and local authorities have been crucial, but according to the *Science and Engineering Indicators—1996*, "these factors are not quite the whole story [because] while many teachers are familiar with reform proposals, most are not" (p. 1.34). All the while, the recurring theme of reform proposals, regardless of the various philosophical stances of the authors, is that the teacher is the focal point of all reform. Reform succeeds or fails at the teacher-level. It is the teacher who translates ideals and dreams into reality. At the elementary school level, where the classroom teacher is typically responsible for the bulk of the education of 20 to 30 children for an entire school year, the importance of the teacher is profound.

So the question is, then, how to change us, the teachers. J. I. Goodlad comments, "What future teachers experience in schools and classrooms during their years as students profoundly shapes their later beliefs and practices. As teachers, they follow closely the models they have observed" (p. xiii). Does this mean that one is destined to be molded by the "ghosts of teachers past"? Does this mean that all of the exciting goals set in such publications as *Project 2061: Science for all Americans* (American Association for the Advancement of Science, 1989) and in the *National Science Education Standards* (National Academy of Sciences, 1996) (NSES) will remain in the theoretical and never the practical realm, that reform can never fully occur while existing teachers live? Must we all die to spawn a new breed? Of course not! We can change, and we must. But how?

Like all professionals, teachers need a variety of opportunities to develop: seminars, college courses, teacher networks, workshops for practicing teachers, journals, science centers, and so on. But we also need to learn science pedagogy in the context of actual students, real student work, and outstanding curriculum materials—that is, in our own classrooms (NSES, p.57)! This need forms the basis of *action research*. We need to learn to teach science as we want our students to learn science. The NSES assert that "Teacher learning is analogous to student learning: Learning to teach science requires that the teacher articulate questions, pursue answers to those questions, interpret information gathered, propose applications, and fit the new learning into the larger picture of science teaching" (p. 68). Thus we can build upon our "ghosts," we can make connections to our experiences, and deliberately and permanently change.

Action research is simply research that is conducted by the teacher in his or her own classroom in order to improve. "...classroom-based research is a powerful means to improve practice," state the NSES (p. 70). But does the term "research" scare you? Does it sound infinitely boring? Consider this: In 1992, A. White, the Director of the National Center for Science Teaching and Learning, testified before Congress, "We find in action research programs that the confidence, the feeling of worth, and the professional behavior of teachers changes immensely when you give them a chance, the time and skills and resources to reflect on what it is they're doing, how it's working, and what they can do to change it so it works better" (p. 17). This is an excellent recommendation for action research. A more complete definition and description of action research is found in the last chapter "So You Want to Do Action Research?"

One of the goals of this monograph is to demonstrate that action research can be done by any teacher in any classroom—by anyone interested in change and improvement. This monograph portrays the action research of four elementary school teachers conducted as a partial requirement for the fulfillment of the Master's of Science Education degree while participating in the Science For Early Adolescence Teachers Program (Science FEAT).

Science FEAT

Science FEAT was a teacher enhancement program based at the Florida State University. The program was designed and implemented by Angelo Collins and Penny J. Gilmer and supported by a grant from the National Science Foundation[1]. Samuel Spiegel was the Program Director. Spiegel, Collins, and Gilmer of the Science FEAT program received the 1995 national award from the Association for the Education of Teachers in Science for Innovation in Teaching Science Teachers.

Science FEAT encompassed three intense summer experiences and, during the two intervening academic years, work done in the classrooms of the teachers. Of 72 teachers who started the program, 59 earned a master's degree in science education, three earned a specialist degree in science education, and two completed the program but were not degree seeking.

The goal of Science FEAT was to improve middle school science education. The program was designed for practicing teachers of grades 5 through 9. Most of the program participants were middle school teachers of grades 6 through 8. However, some of the teachers were from elementary schools (generally grades K-5) and high schools. This program design allowed articulation throughout the K-12 system. Some teachers transferred to lower grades during the Science FEAT program. The research reported in this monograph was conducted by teachers of grades K-6. (See Spiegel, Collins, & Gilmer, 1995, for more information on the Science FEAT program).

How the Papers Came About

The papers that are presented in this monograph are the culmination of a process that started early in the Science FEAT program. The process began when the teachers videotaped themselves teaching in their own classrooms during the first academic year. The following summer they viewed these videotapes in an educational research class designed to prepare them to conduct action research. Many were shocked to watch themselves teach and to see what the students actually did during class. Naturally, the videotaped lessons raised questions in each teacher's mind concerning their pedagogical beliefs and about how they could improve their own teaching. This questioning provided the basis for a research question. The teachers developed a foundation of their topic from the literature, planned a course of action, and conducted the research during the second academic year.

During the research, the teachers met regularly in groups. Science FEAT staff also participated in the meetings when invited. The teachers conversed frequently with a mentor who was either a faculty member or a graduate student. A toll-free help line was provided for research questions.

Drafts of each action research paper were submitted to the Science FEAT staff for review at designated intervals. Each teacher read and provided feedback on two other teachers' drafts. Final drafts were submitted early in the third summer. Each teacher then presented his or her action research in colloquium.

SERVE published and distributed another monograph, *Action Research: Perspectives from Teachers' Classrooms* (Spiegel, Collins, & Lappert, 1995), comprised of papers on the action research conducted by nine of the middle school teachers. These nine teachers were identified early in the second academic year and their research projects were closely monitored so that the monograph was ready for publication just as the Science FEAT program concluded. This monograph has been used around the world by teachers and graduate programs focusing on science education.

Because of the interest generated by the first monograph, we decided to publish the action research papers of four of the eleven elementary teachers in the program. These papers are the core of this monograph. We commenced editing these manuscripts nine months after the conclusion of the Science FEAT program. We interviewed each of the four authors and photographed the teachers

with their students. With each paper we have included an "Epilogue" derived from these interviews which describes the impact of the program and of action research upon each author.

The research exemplified in these papers is illustrative of the research conducted during the Science FEAT program rather than comprehensive. We selected papers for this monograph with which we felt other teachers could identify and empathize.

The Research Papers

Laura Joanos' study, "First Graders' Beliefs and Perceptions of 'What is Science?' and 'Who is a Scientist?'" deals with issues at the forefront of science education, such as why many children seem to show no interest in science. Working with first graders, Ms. Joanos puts forth the very basic questions "What is science?" and "Who is a scientist?" and then assesses their answers. She discovers an effective method to nurture a love of science in her students and to help them envision themselves as scientists. Ms. Joanos' research is an example of perseverance as she shares how she plows through discouragement in the face of apparent failure. Ms. Joanos also provides a great example of the power of communication for teachers who so often, in isolation in their classrooms, wither due to lack of encouragement or communication within the educational community.

Jennifer Yelverton, an experienced and traditional teacher, leaps into the unknown with "Implementing an Authentic Science Learning Experience." She honestly describes the deep feelings of so many teachers that keep them operating in the "safe zone." She relates her struggles and victories as she relinquished control to allow her students to have a real life experience as they inventoried the plants and animals in a soon-to-be nature trail. Ms. Yelverton's experience is an inspiration to those who want to break free from the traditional method of teaching and testing facts in order to promote scientific inquiry, and to those who want to ignite their students' desire for knowledge.

Paul Veldman's research, "Changing a Teacher's Role to Evoke Meaningful Learning Behaviors," began from a reaction to his director teaching style that he observed in videotapes of his class. He deliberately changes his style to that of a facilitator and analyzes the effect this change has upon his students' learning behavior. Mr. Veldman's research, a learning process in itself, remarkably resembles the facilitator-stimulated learning initiated in his class. Equipped with ideas and information taught in his research methods course and the general assignment to videotape himself and come up with a question he would like to answer or a problem to solve, Mr. Veldman began his research. His research stands as an example of how teachers can study themselves, define a problem, systematically institute a likely solution, and observe and analyze the results. It also provides an example of more traditional research and the evolution of learning and method that occurs during action research.

Few teachers have the courage to do what **Toni Haydon** did as she describes in her paper, "Does Student Responsibility for Learning Increase when Students Ask and Answer Their Own Problem Solving Questions?" Ms. Haydon lays out very detailed plans to promote responsibility in her students for their own learning. To the chagrin of her students, Ms. Haydon will not tell them what to do! Instead, she repeatedly presents them with materials and bare-bones instructions to think of a question that can be answered by their own experimentation.

An anxious semester is spent by both the students and the teacher as the students gradually learn to take responsibility for their own learning. Evidence of success, however, is not forthcoming until much later in the year, after the action research has been completed. Ms. Haydon's research is an example of detailed experimental design and perseverance.

How to Do Action Research

The last chapter of this monograph is "So You Want to Do Action Research?", a reprint from *Action Research: Perspectives from Teachers' Classrooms* (Spiegel, Collins, & Lappert, 1995). It offers a practical description of action research and advice from Science FEAT teachers and administrators. This chapter is useful not only to the classroom teacher but to school and county administrators, to university and college faculty, and to anyone interested in conducting or encouraging action research.

The papers selected for this monograph provide portraits of action research . They demonstrate the challenges and rewards involved in action research as each teacher focuses on a goal, relates his or her thoughts and reactions, and critically analyzes the results obtained. Hopefully they will also stimulate ideas for improving your own teaching. These research projects serve as an example of how action research is a viable, effective method of change for the typical classroom teacher. ❖

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Penny J. Gilmer, Ph.D.

Years Teaching: 20

Present Position: Professor of Chemistry, Florida State University

Awards and Accomplishments:

Elected Fellow of the American Association for the Advancement of Sciences

Innovation in Teaching Science Teachers Award, Association for the Education of Teachers in Science, 1995

Principal Investigator Science FEAT, 1993-1995

"Being There" Award, Florida State University

Teaching Incentive Program Award, Florida State University, 1993

My experience with Science FEAT catalyzed a change in my beliefs and practices about teaching. I now employ portfolios, concept maps, and group work in my chemistry courses (Honors General Chemistry; Physical Science for Elementary Teachers; and Science, Technology, and Society), and utilize action research as a way of addressing concerns. Some of my chemistry colleagues are also trying some of these new methods, so the influence of Science FEAT is not only on K-12 schools, but at the university as well.

Science FEAT was a powerful program not only for the teachers in the program but also for the faculty and staff. The ripples from it are being felt at Florida State University and K-12 schools throughout northern Florida and southern Georgia. Many of the Science FEAT teachers have moved to new, challenging positions. Some have returned to doctoral graduate programs in education while they continue their K-12 teaching. Many continue action research in their classrooms.

Jane B. McDonald

Years Teaching: 16

Present Position: Adjunct Instructor of Chemistry, Tallahassee Community College

The impact of action research and Science FEAT on these teachers was phenomenal. Each teacher was already a very successful teacher, yet each radically changed his or her method or philosophy through action research to become more of the teacher for their students that they aspired to be. Reading these accounts and listening to the stories of these teachers has influenced my own educational philosophy and given me many ideas for change.

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Footnote

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CHAPTER ONE

First Graders' Beliefs and Perceptions of "What is Science?" and "Who is a Scientist?"

Laura G. Joanos

Abstract

This study focuses upon the questions, "What is science?" and "Who is a scientist?," posed to a target group of six first grade students. It examines changes in children's beliefs and perceptions after many integrated, activity-oriented experiences that were increasingly oriented toward science. The results of early interviews and samples of journal entries indicate that although students were learning science concepts explicitly and loved doing science, they did not realize it or call it "science." Rather, the children realized this only after repeated references that what they were doing was science and that they were being scientists. Furthermore, the data suggest children could more readily discuss what they had learned when they used their journals as prompts. Changes in students' beliefs and perceptions occurred slowly, even when exposed to many experiences.

Science affects all of us even when we are not aware of it. It permeates our daily lives—our transportation, our health, our machines, our environment, how we accomplish the ordinary things in our lives. It has shaped our history—with medical advances, a greater understanding of the natural world, with how war is waged; and it will influence our future—we will have more technological advances and medical discoveries, more sophisticated weaponry and increasingly more political, environmental, and ethical scientific issues to consider. Thus, science is important to us all.

The overall goal of the new science curriculum of the county in which I teach is: "to develop responsible, scientifically literate citizens who make well-reasoned, data-based decisions" (Leon County Schools Elementary Science Curriculum Guide, 1994, p. 5). To accomplish this, children not only need an understanding of science, but they also need to be able to envision themselves as scientists and to realize that they can do science: They can make guesses (hypotheses), experiment, observe, and any of the other processes involved in science. As teachers, we must create an environment in our classrooms in which science is a less intimidating, more realistic, human endeavor in which everyone can be involved.

Background and Question

When I began my educational research, I was working with older elementary children (ages 9-11 years) in an inner-city school. I was intrigued with the way science seemed to have been taught to these children. The teacher led and directed the science activities, and the students followed along with few opportunities to discover on their own. Later, with different children at a small rural school with pre-kindergarten through eighth grade in one school, I began teaching kindergarten and first grade children (5-7 years old) from lower to lower-middle class economic backgrounds.

As I contemplated my research topic, I realized that these children were not already conditioned from having been in school for five or six years. They had never been taught science from a teacher-centered approach. Did they have an understanding of science? Did they think that they could do science, or could they envision themselves as scientists? According to Harlen (1993): "Children form ideas about things around them long before they are taught about them in school" (p. 15).

Consequently, my educational research developed into and focused on an investigation of my students' beliefs and perceptions of "*What is science?*" and "*Who is a scientist?*" before and after giving the children many opportunities to experience an intensely science-oriented unit into which other subjects were integrated.

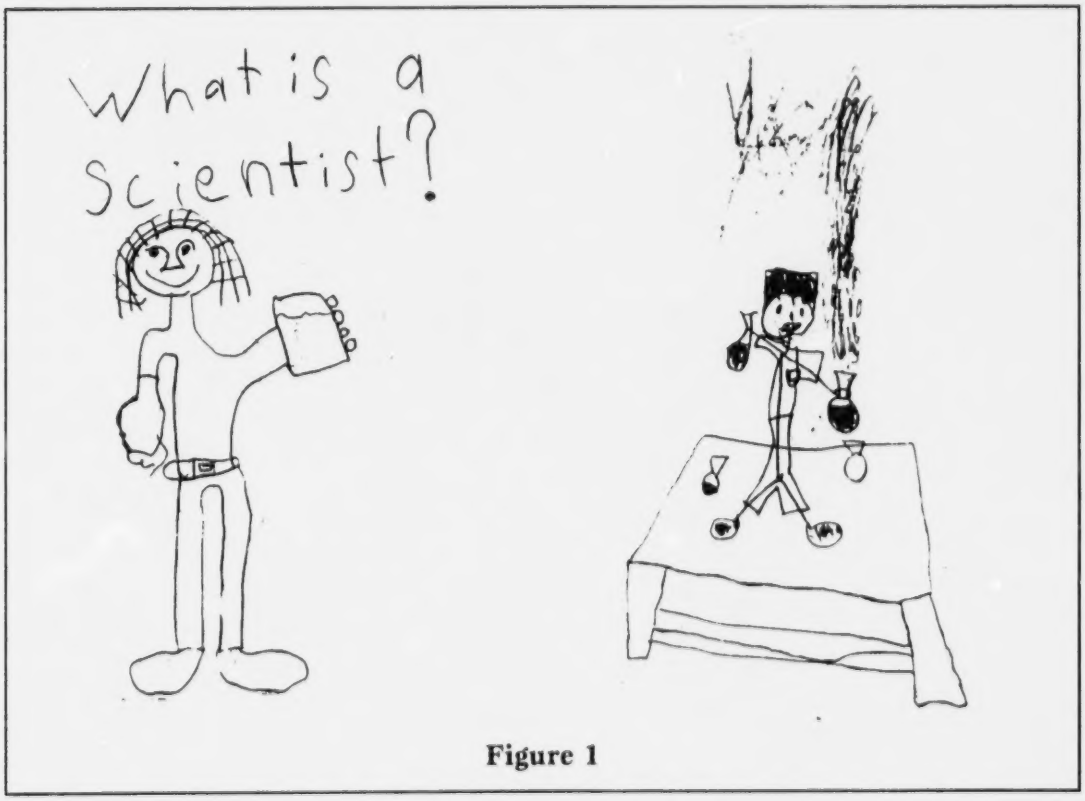


Figure 1

Methods

As I set up my classroom at the beginning of the year, I wanted to create an environment that would stimulate my students' curiosity, build upon their pre-existing knowledge, and encourage them to observe and ask questions. I placed science posters on the walls and provided many hands-on materials. On my science table were magnifiers, balances, shells, and a variety of items that I changed with each topic we studied. In addition, on each desk, I provided worm farms or other projects.

The population of my classroom would be changing at some point due to the fact that we were getting another kindergarten teacher to alleviate overcrowding. With this in mind, I used a group of six first graders–three boys and three girls–as a target group from which to gather information.

I planned to interview the children and use their daily reflection journals as sources of data. My goal was to interview each child after each unit of study and to read and analyze several sample journal entries throughout each unit.

I taught the first unit as I usually did, equally integrating science, math, and language arts skills all into one topic. The topic for this unit was "Apples." We made a class list of what we already knew about apples and then a list of what we wanted to learn. We explored these questions. All subjects, of which science was one, were taught using apples as a point of focus: We read books related to apples, counted apple seeds, made art pictures with apple prints, and wrote about apples in our journals. As science activities, we soaked apple seeds and observed them before we planted them, looked at the various parts of an apple blossom and labeled them, made a booklet that showed the growth of an apple seed from seed to tree, and observed and tasted the changes in apples when making apple sauce. We did not discuss being scientists or what science is or which activities were science, although we had done many.

The next step in my research was to assess the children's' beliefs and perceptions about "*What is science?*" and "*Who is a scientist?*" after this typical unit and before an intensely science focused unit. I asked the children to draw and write about "*Who is a scientist?*" in their journals. They each drew a picture (see Figure 1), but because the children varied in ability level, some of the children wrote a sentence telling about their pictures, while many dictated a sentence to me.

I also audiotaped an individual interview with each child in my target group over a period of one week while the other children were outside at free play time. I asked two questions:

- "What is science?"
- "Who is a scientist?"

Then to clarify and elicit more discussion from the children I asked

- "What kind of person is a scientist?"
- "Describe what you think a scientist looks like."

"Who is a scientist?" "Somebody that does experiments and finds bones. Old people with beards. Just men."

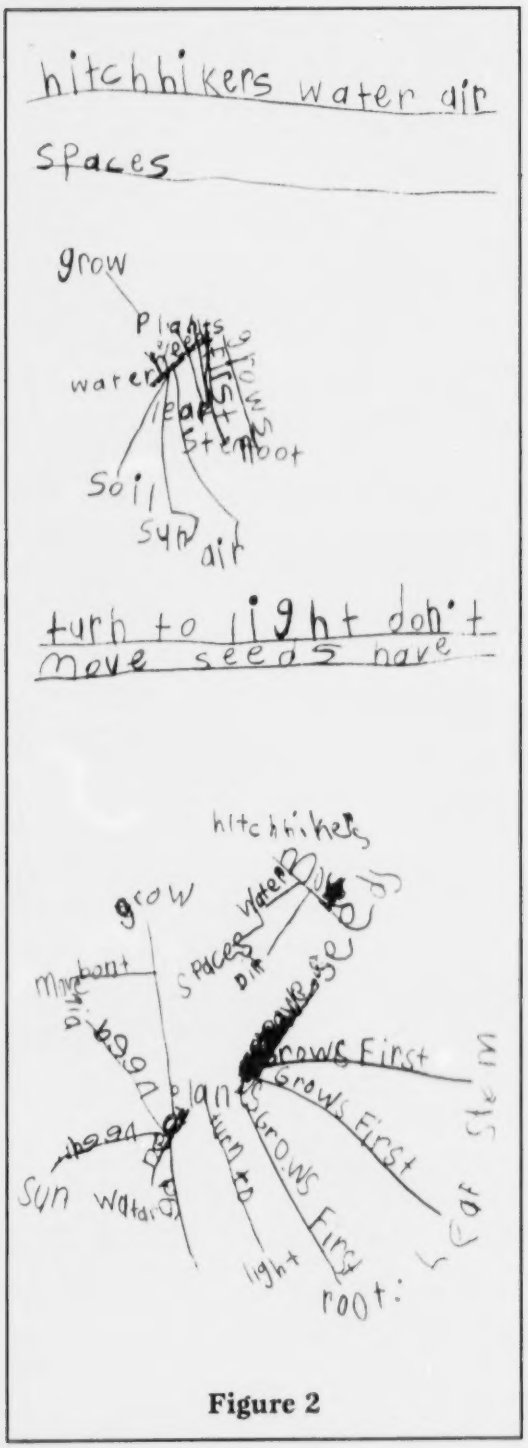


Figure 2

- "Have you ever met a scientist?"
- "Are you a scientist?"
- "Could you be a scientist?"
- "Have you ever done science?"

Next, I conducted a unit on plants and seeds. We made class lists and explored the questions as we had with the Apple unit. Again I used an integrated, activity-oriented approach to the unit. This unit, however, was different from my usual method because I now integrated the other subjects, such as writing, reading, and mathematics, into the specific science unit of plants and seeds. For example, the students now, rather than simply reading a book that had plants or seeds as a topic, actually read scientific books about plants and seeds. Everything we did was definitely science-oriented. We had, what I would consider, an intense science unit!

At the end of the unit we created an impressive concept map for the class which I used as an assessment tool. Students copied their version of it into their journals (see Figure 2). It showed the phrases/words/ideas the children knew related to a given concept and how the phrases/words/ideas are connected to each other. I interviewed and sampled journals again.

Results

After the Typical Unit: Apples; Before the Intense Science Unit

When I asked the question, "*What is science?*", their answers were:

- **Student 1 (Girl):** "Mixing things. Making things that haven't been made

before. Making things that haven't been discovered. Dinosaur bones because they have to search for them, dig for them and look for them."

- **Student 2 (Boy):** "Something you learn. Balancing things."
- **Student 3 (Girl):** "They balance stuff. Do math."
- **Student 4 (Boy):** "It's something you got to know to learn other things about the moon and out in space. Looking into bodies. Snakes and poison."
- **Student 5 (Girl):** "Pluses."
- **Student 6 (Boy):** "People digging dinosaur bones and eggs. Doing experiments on air and weight."

I initially thought these responses were coming from the students' previous year's experiences. After I reflected on their answers, I realized that science activities that we had done very early in the year, prior to this study, were evident in their responses, (e.g., scale and balance activities).

My next questions, "*Who is a scientist ?*" and "*What do you think a scientist looks like?*" received a wide variety of answers:

- **Student 1:** "A scientist is someone who has to have glasses. They have to have white clothes and shoes on. They have to be old. Can be a boy or a girl."
- **Student 2:** "He's a person that does science. Makes potions. Makes a life."
- **Student 3:** "It's a person that does all kinds of different things. They have hair, arms, clothes. Can be a man or a woman."
- **Student 4:** " A scientist is a surgeon or doctor or specialist. They look into bodies. Pick men to go up in space. Look real old because he couldn't know as much. Men or women if they want to be."
- **Student 5:** "He's a person. He has on a white thing. Uses a magnifying glass to see things. Has potions. All kinds of

"When I asked if they were a scientist they all said, 'No.'"

"...Children not only need an understanding of science, but they need to be able to envision themselves as scientists and to realize that they can do science..."

people can be a scientist: Americans, Chinese. Ages could be 22, 34, 33."

- **Student 6:** "Somebody that does experiments and finds bones. Old people with beards. Just men."

I then asked if they had ever met a scientist. They all responded, "No," but several said they had seen scientists on television! When I asked them if they were a scientist they all said, "No." All students answered that they could be a scientist, however.

The last question in this interview was *"Have you ever done science?"* Their responses once again were varied but also reflected some of the science activities we had done in class (i.e., using the scale and balance, making play dough, measuring water, cooking apples, mixing hot and cold water experiments).

- **Student 1:** "No, but I tried to cook before."
- **Student 2:** "Yes! Balancing rocks and shells on the scale."
- **Student 3:** "Yes. Doing math and putting beans in a cup."
- **Student 4:** "Yes. We made some play dough. Did things with hot and cold water. Measuring water projects."
- **Student 5:** "Yes. The pluses."
- **Student 6:** "Yes, here once or twice. Made play dough."

After the Intense Science Unit: Plants and Seeds

Because the students had been able to recall an amazing amount of information as we made our concept maps, I anticipated their answers to these questions to be about all the science activities we had done in class and all the science things they had learned. I was in for a shocking surprise!!

When asked, *"What is science?"* they responded:

- **Student 1:** "Making things. Mixing colors. Making things you've never seen before. Dinosaur bones."
- **Student 2:** " I think it is something that you guess. Making guesses like math is really hard, and you guess the answers. If I was a grown-up, I'd look in the dictionary to see if I was right."
- **Student 3:** "They pour blue and red stuff in the little like cups but a tube. Sometimes it's math, take-away."
- **Student 4:** "All kinds of stuff that scientists do. Sometimes they mess up, and when they mess up they go over it again and see if they really did mess up, and if they did, they go again. They do it over again and, if they keep doing it wrong, they just look it up again. They'd figure out what was the matter when they were wrong. They explore the world. In pyramids, they found sand that was buried. Found a room with a king in it. When they looked in there they may see secret passages in the room that nobody in the world has knowed about. They have to read this thing. They read that to know where the booby trap or secret passage way opens."
- **Student 5:** "A person who thinks things. Science is pluses, numbers, letters and that's all."

- **Student 6:** "Something that you look up like dinosaur stones and make guesses and see if you're right. Can't remember the name of it. Answers and discover stuff."

The students' answers to *"Who is a scientist?"* and *"What kind of person is a scientist?"* were relatively unchanged. For example:

- **Student 1:** "Boys or girls can be scientists. They can be whatever they want. They wear white things, white shoes—everything white. They have beards and glasses. They try to figure out things. Guess at things. Mix things up."

When asked again if they had ever met a scientist, the students said, "No." When asked if they were a scientist, all but one replied, "No." When asked if they have ever done science, the students replied:

- **Student 1:** "Yes."

"I had assumed that the children knew we were doing science, but their responses indicated they did not."

- **Student 2:** "Sometimes. I guess about things."

- **Student 3:** "Yes, last year. We sorted beans. We done math. In kindergarten. This year, math, take-away."

- **Student 4:** "Probably once, but I don't remember if I've ever done it. [To clarify, I asked, "Think about here at school."] "Well, I don't know about that. It's 98 days of school, and I don't think I've done a science project yet. But when YOU have spoken, you said that it was a science activity like the water activity." ["How about things you've done?"] "Well, that stuff was not like original science. It was kinda like when you're starting science. Like you measure and heat and see how hot it is. If you want to grow up and be a scientist you have to graduate all through the way through school."

- **Student 5:** "No, yeah. Numbers, pluses. Painting and drawing."

- **Student 6:** ["Are you a scientist?"] "No, but I've done scientist things. Like beans. They have like... we opened them up and they have vine things. If you wet it the shell thing comes off and it's wet."

After hearing the children's answers, I was truly discouraged. Many of them said the same things they had said previously, even though we had completed an intensely science-oriented study on plants and seeds. I had assumed that the children knew we were doing science, but their responses indicated they did not. My expectations were not met. As Osborne and Freyberg (1985) stated: "Some teacher assumptions can undercut teaching effectiveness" (p. 91). I felt that my teaching had not been as effective as I had thought it had been.

When sharing these experiences with other teachers, it was pointed out to me that the students were learning but, to them, they were doing "school things," not science specifically. Asking them to answer the question *"What is science?"* might be too abstract for them. My peers suggested that I ask them to discuss topics in their journals. This might disclose more of the science concepts they had truly learned and help enhance their perceptions of science. Thus, I

decided to use their journals as prompts in the next round of interviews.

The children were very eager to talk about what they had drawn and written in their journals. The students were also able to explain the science concepts we had studied in more detail. For example:

- **Student 1:** [On clouds] "There are different kinds of clouds. Stratus, cumulus. Inside the clouds there are little tiny rain drops . They go faster and make lightning."

- **Student 4:** (On plants) "The seed keeps on getting bigger. The root grows first. Then the stem grows second. I learned plants need water and dirt to grow, also need air."

- **Student 6:** (On plants) "Seeds float away from the parent plant because they are close together. It would be hard to grow. The roots would get together. Can't grow good."

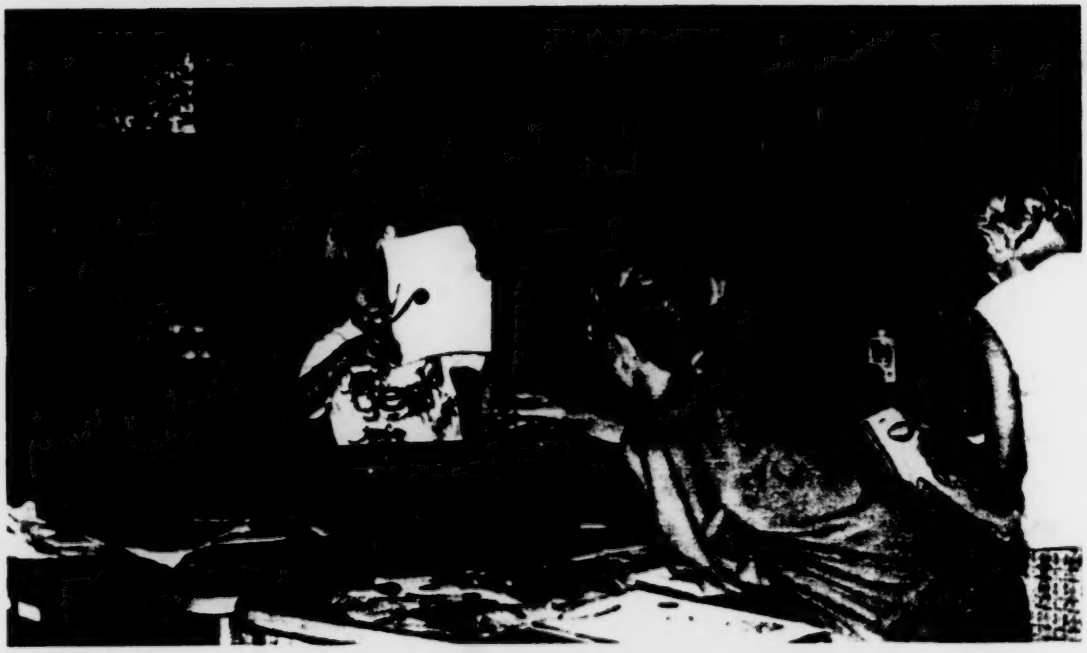
None of the students, however, said without prompting that they were doing science or being scientists. When I specifically asked the students to think about what they were doing and if they were doing science, they all said they were doing science. Several even said that scientists observe things and that they were being scientists when they observed the weather, clouds, and wind.

Conclusion

The purpose of this research was to discover what a group of first graders' beliefs and perceptions were on *"What is science?"* and *"Who is a scientist?"* I also looked at how these beliefs and perceptions changed after many activity-oriented, increasingly science-oriented experiences.

The results of this study have shown me that my students love doing science, they just did not know they were doing it. My students did not realize they were acting as scientists nor were they calling their activities "science." However, they were enthusiastic and very able to recall information about what they had learned, as shown in both the interviews and journal entries of the target group. This realization did not occur until regularly repeated references that what they were doing was science and that they were

"I plan to continue an integrated, activity-oriented science curriculum, but, as I do, I will steadily refer to our work as science and that we, the students and I, are being scientists as we discover together."



being scientists. As Brass and Duke (1994) stated: "When children begin to understand that they can do science and that they can be involved in the study of science, then they begin to see themselves as scientists and can do science; they can take chances, make guesses and hypothesize" (p. 108). This occurred in my class!

Brass and Rudd (1994) also expressed: "All children can think scientifically to a greater or lesser extent, and even those children who find science difficult are very capable of thinking for themselves in their own way. One important aspect of children developing in this way is that the teacher's role in the classroom also develops"(p. 121). In this study, I learned that unless I, as the teacher, refer to what we are doing as science, my students do not realize they are doing science. As I facilitate their learning, I, too, am learning and growing. The constructions I have made from this experience will enable me to be a better facilitator of my students' learning.

Implications

Changes in students' beliefs and perceptions occur slowly even when exposed to many experiences. As Marshall (1994) stated: "Change is not something that happens over night. It is not something that happens in one school year. It is a gradual process with subtle changes occurring along the way" (p. 91). Consequently, I plan to continue an integrated, activity-oriented science curriculum, but as I do, I will steadily refer to our work as science and that we, the students and I, are being scientists as we discover together.

Science permeates our daily lives. While knowledge and skills of a unit can be science-based, teachers should stretch beyond subject boundaries and give children experiences which integrate science into their lives with meaning and purpose. Then, if the teacher also makes the students aware of the many

ways they are doing science, the students can conceive of themselves as being scientists, and science will be exciting and important to students as they progress through their school years and into adulthood. ❖

Epilogue

by Jane B. McDonald, Editor

Ms. Joanos was an elementary school teacher who felt weak in the science area. Previously she had taken what she calls "stabs" at improving her background by attending workshops. But she never really got comfortable with science until she completed the Science FEAT program. After the program, Ms. Joanos intensified the science content in her class. Her students love science. She has impacted her school and teachers county wide and received the Teacher of the Year award from her fellow teachers. The action research component of the program dramatically revolutionized her approach to science in her classroom. She began the next school year emphasizing science and what a scientist is and does, and, she used science terminology daily. Ms. Joanos integrated science so thoroughly into all of the activities during the day that science became a natural, everyday occurrence to these students. Then, at the end of the year, in response to the questions "What is science?" and "Who is a scientist?", many of the children made comments such as, "I'll just draw myself," or "I'll write about when we studied soil." Her students realized that they were doing science and were able to envision themselves as scientists, which was the goal of the change that she had made and used as her research topic. She has considered a follow-up questionnaire for the subsequent teachers of her students to evaluate any long-term impact she has made.

Ms. Joanos has also shown the importance of sharing what you learn. She has not hoarded her knowledge for herself but has passed it

Laura G. Joanos

Years Teaching: 16

Present Position: K-1 Teacher

So many people go to work and do not enjoy what they are doing. This is not the case for me! The shining eyes, the hugs, the lovingly scribbled pictures, are just a few of the daily rewards teaching gives me.

Action research has made me more aware of myself and what I do in the classroom. It is a pretty easy method to improve yourself, to set a goal and make changes. If you are interested in doing action research, have someone you can bounce ideas off of.

on generously to her fellow teachers. At both her former and present school, she organized and conducted a week's worth of hands-on science activities in the context of a "Science Days" event . Ms. Joanos has held school and countywide inservice as a member of the county Science Cadre. She has written two grant proposals and received funds with which she has purchased science materials to implement the new county science curriculum not only for her class but for each of the other first grade classes and to share and work with the other first grade teachers. Consequently, the teachers at her school have increased the science content of their own curriculum. One teacher said, "Laura is always willing to listen, to give suggestions, and to help smooth the road for teachers who are science-phobic. Laura's enthusiasm for science has gotten me, my students, and the whole school excited about science."

Ms. Joanos also benefited from the Science FEAT and action research experiences. She is no longer intimidated by science and can see for herself, as she wrote in her paper, how science is so important and permeates our lives. Ms. Joanos now considers action research a very doable method of positive change in the classroom, something that any teacher could use. She is excited about the "ripple" she has made with her students and other teachers and dreams of a science "tidal wave" as more and more teachers are influenced by science education research.

Jane B. McDonald

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CHAPTER TWO

Implementing an Authentic Science Learning Experience

Jennifer W. Yelverton

Abstract

An experienced, traditional, 5th grade teacher implements and evaluates an authentic science learning experience. Her class inventories the schoolyard biota, researches and identifies each specimen, and publishes the results in a reference book for the school library. The teacher finds that meaningful learning has occurred. Students develop research skills, grasp the concept of science-as-research, extend their knowledge, and become very motivated. She also struggles as she develops an alternative student learning assessment required by the study.

For sixteen years I stayed on the literary side of science and taught science primarily as a reading course. My students, after all, were evaluated annually by a standardized test that measured their ability to read and choose an answer from a list of choices. Science was simply information to memorize. I was taught science in a textbook style. Practical applications, although discussed in class, were never experienced. I had no applicable understanding of the concept of science as a process as well as facts—or of how to teach this concept in a meaningful or productive manner.

I stayed in a safe zone in which learning was simply arriving at answers in the teacher's manual—the *right* answers, and where grading could be standardized and justified. To provide students with problem solving and reasoning experiences would allow too many options for answers! Surely, if I just taught my students how to comprehend the text, define vocabulary, and label the diagrams, I was doing my part to educate them in the science curriculum.

Yet, I thought repeatedly, "These children can't think. They don't reason." In reality, I was not asking them to do so. Eventually, I realized that I must provide the students with opportunities to think. The students needed experiences that encouraged exploration and discovery and provided choices in decision making and problem solving, and, yes, even allowed a variety of answers.

"I stayed in a safe zone in which learning was simply arriving at answers in the teacher's manual—the right answers."

"To provide students with problem solving and reasoning experiences would allow too many options for answers!"

So much time in our schools is spent in learning but not in understanding. I define *learning* as the process of accumulating information and the ability to recall it in the form of memorized terms, definitions, or sequenced events. Frequently, learning is short-term, i.e., the material is memorized and quickly forgotten after serving its usefulness (the test), recalled yet not understood because it has no relevance to the learner.

In contrast, *understanding* is, as Perkins & Blythe (1994) suggest, "...a matter of being able to do a variety of thought-demanding things with a topic [such as] explaining, finding evidence and examples, generalizing, applying, analogizing, and representing the topic in a new way" (p. 5). Understanding requires one to take learned information and make sense of its relationships, to relate it to different situations and grasp its purpose and meaning.

Students, I realized, might best learn and understand concepts that had meaning and value in their everyday lives as Sorohan (1993) suggests, "...we embed learning in our individual experiences" (p. 48). Thus, a teaching technique that included authentic science experiences could result in long-term learning and understanding for my students. *Authentic* means having "real world" implications and first-hand applications as opposed to being staged in the classroom with no apparent relevance to students' lives. As Newmann & Wehlage (1993) explain, "A lesson gains in authenticity the more there is a connection to the larger social context within which students live" (p. 10).

For this study I incorporated an authentic learning experience into the science curriculum of my fifth grade classroom. I believed that this would provide my students an opportunity to understand "science as research" by doing science authentically as they gathered, recorded and published scientific facts, extended their knowledge to new situations, and realized that science is more than facts. I thought that this experience would help them to learn scientific research skills such as observing, making predictions, gathering and recording data, researching scientific literature, and drawing conclusions. This study focuses on the implementation of this teaching technique to determine if authentic learning experiences are effective in helping students learn scientific skills and facts and in developing their understanding of science-as-research.

Method and Results

The Authentic Learning Experience

An area behind the school was to be developed as a nature trail by all grades and thereafter used for hands-on science curriculum. Our authentic experience would be to inventory the existing plant and animal life in the area and record that information in a reference book for the school library. The inventory was a "real life need" for our school because the area needed to be assessed before development by the other grade levels could proceed.

To consider this authentic learning experience effective, I decided the technique used in this study had to (a) provide students with opportunities to make personal discoveries related to the process of scientific research; (b) provide students with opportunities for

decision making and problem solving which in turn lead to a variety of answers to questions; and (c) engage students in learning science facts, ideas, and skills in ways meaningful to them and valuable to their daily lives.

To evaluate the effectiveness of this authentic learning, I used my lesson plans, a daily journal in which I recorded my observations and frustrations, and an assessment of student learning made from the content of students' journals, my observations of group discussions and activities, and the quality of the final written reports.

My Lesson Plans

My first lesson plans were very general: discuss the project, give the purpose, have students inform their parents of their research project, and make a decision about a topic in which to specialize. I loosely structured my plans so that I could guide the students through the research process of the inventory. Also, I wanted my students to have input into planning the activities.

My objective was not only for my students to learn specific information but for them to also explore and discover, make decisions (particularly about the direction of the study), and solve problems that arose. I hoped this experience would interest the students and be relevant to them. I realized that while I could provide the same opportunities to all students, their responses would reflect their unique needs as individuals.

As the project progressed, the plans became more focused on the discovery and documentation of the biota, and student input increased as they began to see the study as their own. Day-to-day activities were based on their need to know more about their specimen and arose from the students' own curiosity and interest. Otherwise, the students would have been following my directives to achieve my goals rather than their own.

How We Implemented the Authentic Learning Experience and My Observations

1. First we discussed the project and decided upon four research teams, each comprised of six students, to study one of the topics: trees, grasses and flowering plants, vertebrates, invertebrates.

This began the authentic experience and also presented the students with the problem to solve.

It was immediately evident that all teams were not equally staffed after the students had each selected an area in which to specialize. The students brainstormed and decided to vote to select a solution. The winning solution was to spin a bottle, let the student at whom the bottle pointed select an area of study, and to continue this process until each team had six members.

I wrestled with the idea of asserting my 'teacher power' because I felt sure their solution would never work. Everything

within me, my teacher training and experience, my parental urgings, my adult/child relationships, cried that I should settle the problem quickly and efficiently. But, against my better judgment, I let their decision prevail, standing by awaiting disaster, while the students selected a leader, implemented their idea, and solved the problem with not one argument or complaint. The students had been successful, and had I intervened, I would have denied my students an authentic opportunity to experience problem solving and decision making. I struggled with myself to provide this opportunity for my students and because I did allow it to progress in this manner, we all won.

2. Each team was then given the responsibility for planning and completing a task.

What a wonderful opportunity for each student to participate on a team! They eagerly designed a plan of action. I allowed them to determine which method would work best for their group. They were in charge, empowered to make any decisions necessary to accomplish the task in their particular area of research.

Plans recorded in their journals ranged from the simple: "Don't kill the animals," to the specific: "I will do the camera, [He] is going to do the jars and the tweezers...." One team included a diagram with a key showing the location of each team member on the trail during the outdoor time and instructions for bug collecting: "Gang around him. Someone traps him with [a] net. Someone slams [a] jar on him."

3. An explanatory letter with a permission form was sent to parents. The students discussed and wrote safety rules in their journals and then explained them to the class. They also took short "field trips" on the nature trail area to help them develop observational skills, establish acceptable outdoor behaviors, and become familiar with the surroundings.

Rules evolved from outdoors experiences such as: "Don't cut yourself!" and, "Don't jump on the benches!" Some showed their concern for life: "Don't kill the animals," and "Don't harm the plants." Others revealed an insight into the need for cooperation: "Stay together," and, "No fighting!"

4. Finally, after a review of our long- and short-term goals and with clearly designated duties and plans to find,

sketch, photograph, describe, and identify ten[1] different specimens in each of the four research areas, the students were ready to begin.

Energy and enthusiasm were finely tuned by this time.

5. For three consecutive days, students worked in the nature trail area observing the plant and animal life, writing descriptions, photographing specimens, and contemplating their discoveries.

The first day of outdoor exploration was fun and exciting. The students worked together and independently, both on and off task. Often they would call out in excitement, "Come see what I found! You've got to see this!"

"What are they learning?" I wrote in my journal, " I cannot tell by observing. They at least seem to be having a good time and are happy about their activities." I hoped they would reveal some evidence of learning in their journal writings.

6. Every day the students wrote a more detailed explanation of the work they had done and their thoughts about the experience.

Students needed little encouragement from me as they began to write about their experiences. I, of course, hoped they had learned something meaningful in the process.

"I was surprised at the trees we found because I thought they were all oak trees, but they weren't. There were dogwood, oak, pine, and cedar... I had a great time," one wrote; from another, "I thought there was just trees and grass out there." As I read these comments, I knew that these students

had recognized the diversity of the area and developed observational skills. For one of these two students, in particular, my teaching efforts had so far been ineffective when I simply tried to "show-and-tell" the information. But now this student searched and explored, motivated by his own curiosity.

Some discoveries were certainly not in our plans. They often occurred during what I considered off-task behavior: "Today we tagged four trees.... I never knew what a magnifying glass could do. The only thing I did know was that they made things bigger. The magnifying glass can start a fire. [He] did, but he put it out." These comments were evidence of a personal discovery that was meaningful to this student.

Another example of this came from a student inventorying vertebrates. He wrote, "I saw a whole bunch of stuff. [My friend] caught a bee and a hornet in his net... I caught two wasps with my bare hands. I saw a bluebird that could fly really, really fast. We didn't catch anything in our animal trap. [He] caught a butterfly and named it DUD because it had a broken wing...." His journal, though not indicative of him completing his

task, was crammed with detailed graphs displaying data collected from other groups. Had I been looking for a right answer from this student, I would not have found it. What I found instead was that his curiosity and interest led to the most sophisticated data analysis, in the form of graphs, I have ever seen produced by a fifth grader. After sharing his journal entries with the class, other students began to graph their own data.

Other discoveries were more social in nature. For example, one student shared, "When we got outside we got to work....Then we started working as a team." Plans made in the classroom had now become a reality for this student.

For some the outdoor explorations were simply fun. Their journals contained these insightful remarks: "I liked being in the tree group. Looking at trees is pretty cool." "I finished my research [and] began to look around with my friends. But that got boring. I just hung around with my friends, the only thing that I learned today was have fun when you're learning." But, as I read the entry I thought, what a wonderful thing for a student to discover! "I learned to have fun when...learning."

"What an urgency I saw—what a demand for more information! All of their energy was directed toward finding out, learning, toward satisfying their own curiosity."

Another positive outcome was that students wrote prolifically of their experiences. One girl commented after reading aloud from her journal, "I am writing like a scientist!" The whole experience proved to be an excellent motivation for developing writing skills.

7. The next week they spent in the library researching the literature.

As the students planned their library activities, I heard them voice their need to know more about the samples they had collected and photographed or to confirm or resolve any questions about the identity of a sample. They discussed possible sources of information. I noted in my journal that on several occasions various students commented that they "*needed* to go the library *now*" although a number of reference books were available in the classroom. What an urgency I saw—what a demand for more information! All of their energy was directed toward finding out, learning, toward satisfying their own curiosity.

Consequently, discoveries continued as the research moved indoors to the library. Several entries in journals were similar to what one student wrote, "I had [to find information about] the dogwood tree. I looked, and looked, and looked, and looked, and looked, but there were no books on the dogwood tree. Then it struck me so hard, look in the encyclopedia...I didn't know if I was struck by lightning or an idea...."

Another student was committed to proving a certain tree was a 'falconer' tree. He wrote, "I experienced...how to look up [information]... sometimes we were wrong, but we did a lot of research to find what [the tree] really was.... But there was this one tree [that was] such a problem, we thought it was a falconer tree, but that isn't a tree." Even so he did not easily give up his identification. He was questioned many different times as to why he thought it was a falconer tree. Although

he gave no reason for his belief, he searched and searched hoping to verify the name. But by comparing leaf samples and descriptive information and talking it over with his teammates, he was finally convinced that the tree was not a "falconer" tree but a hackberry tree. Learning produced from this personal controversy would be much more meaningful than if I had simply given him the answer. I thought, "This discovery will have more impact upon him than anything I could tell him." This was relevant to this student's life and a wonderful example of the power of curiosity.

These were indications to me that these students had focused on their topic and had begun to discover and develop the scientific skills of making predictions and observations, and analyzing data—capabilities not taught by definitions in a textbook or by my demonstration, simulation, or instruction. This process had developed naturally in response to a real-life situation in which the students, responding to their personal decision to explore, sought answers to questions generated by their own curiosity.

8. Each student was to complete a research paper that included a description of one specimen, its common and scientific names, and a bibliography. Each team was responsible for a total of ten papers, those done individually by each member plus four for the group to complete cooperatively. When the identification phase of the research was completed and discussed, we typed and printed our data, then organized it in a binder which we placed in the school library as a reference book for the school nature trail. Students added photographs, sketches, or dried samples of leaves or flowers to each report and covered each page with a plastic sleeve.

When the reference book was completed I posed this question to the students, "Now that you have worked as scientists, what will you do if another student says, 'I don't believe you have identified this plant or animal correctly because...'?"

After consideration, one responded, "If they give me evidence, I will have to consider that I may have been wrong. I have been wrong in identifying things before, and I may be wrong again." This indicated to me that the students grasped the concept of science-as-research, science as a process, with insights based on evidence. Also, he showed confidence in his ability to assess new information and draw a conclusion divergent from his original.

Assessment of Student Learning

To assess learning of science processes, I looked for written evidence in student journals, oral evidence during group discussions, and physical evidence of the students at work. I used the written product (the paper) of the research to correlate these observations to facts in the literature.

Informal sources provided insight for me into the students' learning that could never be

"I could have never delivered such an authentic learning experience to my students with my former science-as-facts-to-learn approach."

captured by traditional on-paper tasks: Student journals contained entries such as, "I never knew that....," "I always thought that....," "I finally realized that...." They frequently huddled in groups either to observe, discuss, question, think, rethink, or plan. They stood, knelt or sat to write and sketch data. Students shared personal experiences and discoveries in small groups at lunch time at a picnic table. Each person's response to the day was quite unique and reflective and continually expressed fascination for their work. They communicated their experiences and data orally in group presentations and in written form as the final paper. I interpreted all of these as an indication of learning.

One student, however, with a learning disability and a history of disruptive behavior, gave no evidence of learning science concepts in his journal or of developing scientific research skills. During group presentations he listened and showed interest in each discussion, but he added few remarks. When I asked him directly what he had learned, he always shrugged his shoulders and replied, "I don't know." With very little evidence from him in writing, oral responses, or physical activities, I assumed that he had gained nothing from the experiences. However, a conference with his mother revealed that he was enthusiastically extending his school experiences at home by collecting insects and plant samples in his own yard. He was noting details and making observations and comparisons of his specimens and asking his mother for help in their identification.

Discussion

From this evidence, I am convinced that my students have experienced opportunities to explore and make personal discoveries, to make decisions and solve problems, and to develop a meaningful concept of science of practical value to them.

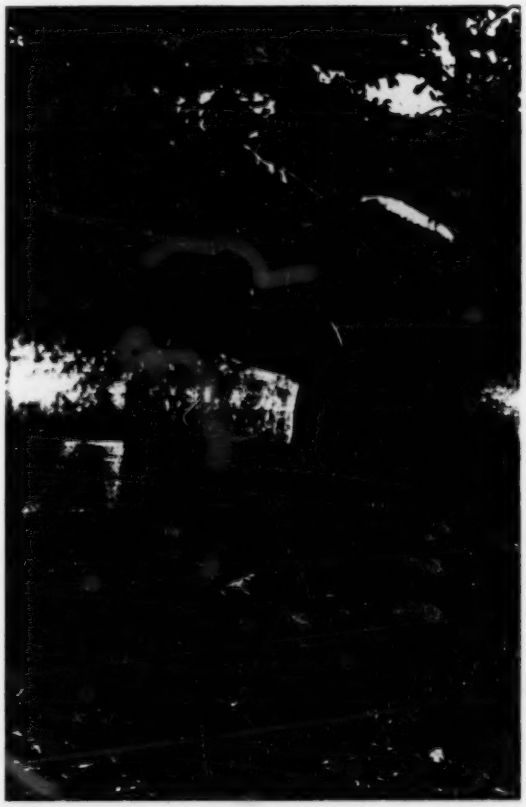
The students together solved the problem of assuring the coverage of all the topics, and they, in groups, made decisions regarding their plans of action and the safety rules. They all certainly explored as they hit the nature trail and discovered the variety of trees and animals. One student even found out what a magnifying glass could do. They made discoveries in the library, too, as shown by the dogwood tree research and by the falconer versus hackberry tree dilemma. They based their conclusions on data gathered during their explorations and on information in the literature, not on me having provided them the "right answer." The research process naturally evolved from the project requirements and their own curiosity. The students had been given the mission to "inventory the wildlife." They had accomplished it by planning, exploring and discovering, gathering and verifying data, and publishing the results, all of which are parts of science-as-research. I could have never delivered such an authentic learning experience to my students with my former science-as-facts-to-learn approach.

Although I believe a need exists for students to learn scientific facts, and perhaps drill and practice, oral and written experiences are

effective methods of instruction, the outcome I desired was that the students understand science as a research process and gain the skills and knowledge to solve a problem. This authentic experience provided multiple opportunities for these types of learning to occur. I have related specific examples of only a few students in this paper, but I believe that all of my students benefited from this project. They all learned, as exemplified not only by the journal entries and the published reports but also by the one student who made the graphs and the other student who, although doing little at school, extended the activities to an at-home learning experience. These students learned something of importance to them, not to me or to the curriculum, although this was the desired outcome of both.

My failure to detect learning in the student for whom learning mostly occurred at home with his mother led me to question the purpose of assessment and how I might better assess learning. For many years, I have been aware that students are unique learners, using different modalities—auditory, visual, tactile, and kinesthetic—to process information. To meet these needs, I have now varied my methods to provide learning opportunities for all modalities. In the past I always provided the same information in the same way to all students, thereby guaranteeing my fairness in teaching and learning assessment. I felt obligated to be objective, to come to the "right" answer myself in the form of a justifiable, standard grade for each student. I felt safe with the traditional textbook-and-test method of instructing students. Many times, however, I sensed a need for a change in my instructional practices, in my expectations of learning, and in my testing (assessment) methods. I am now much more willing to try alternative forms of teaching and assessment. I have seen and can confirm that learning can occur and be evaluated in a nontraditional manner.

As the research drew to its conclusion, I found myself reflecting upon my beliefs about teaching and learning. In view of what both I and the students have learned from this experience, I wonder if my emphasis on teaching students should now shift to helping students to learn. I know that I want to continually reconsider my beliefs and to search for the most effective techniques in science education. The evidence supports and encourages my belief that authentic learning experiences are a most enjoyable and effective science teaching and learning technique. ❖



Epilogue

by Jane B. McDonald, Editor

Ms. Yelverton has always been immersed in the educational world. She comes from a family of teachers—her aunts and cousins, and now her daughter. She began teaching school immediately upon her own graduation from college and has taught fifth grade for eighteen years at the same school. As a result, Ms. Yelverton had fallen into the trap of feeling required to measure up to various expectations. However, Ms. Yelverton longed to bring the outside world, or "real life," into her classroom, and she had, with projects centered around practical concepts such as recycling and composting. She had also sponsored ExploraVision[2] teams, one of which won first place in a national competition, that link the business and engineering community up with students. But Science FEAT provided the opportunity and the impetus for Ms. Yelverton to finally dare to relinquish control and to experiment with a truly authentic experience that had no well defined plan or means of assessment. She is still, after a year, obviously excited to have broken out of the traditional mindset. In her own words: "Surviving this experience has set me free!"

Ms. Yelverton has continued to implement authentic learning experiences into her curriculum at every opportunity. Through participation in the Florida EXPLORES![1] program, she obtained her very own satellite antenna that perches atop her classroom. A computer in her room receives weather data directly from the satellites that pass over the

Jennifer W. Yelverton

Years Teaching: 22

Present Position: 5th grade Teacher

I want my students to have more experiences, more time to do the thinking, to make choices and decisions, instead of me doing it all. The world outside of school has different expectations. I want to bring this outside world into my classroom.

My evaluations of my teaching had always been based upon my feelings—did I feel like that was a good thing I had tried with the children. When I did action research, I had documentation to evaluate—words the children had written, products they had made, or notes I had taken that I could use to help me analyze what I had done. Doing action research forced me to keep up with myself.

school. These satellite images have made a variety of concepts, such as latitude, longitude, negative numbers, and graphing, real to her students. Ms. Yelverton is participating in Project CHILD[4], a program designed to incorporate computer technology into the curriculum and has increased the use of computers into her math curriculum. At her school, she has instituted an annual Olympiad which is a hands-on science/math carnival. She has also collaborated with other faculty members to implement a microsociety in her school. Thus far they have begun a schoolwide postal service (inspiring prolific letter writing) which they hope to expand to a working and banking system. She and others are currently involved in writing grant proposals to fund this school-wide authentic learning experience. Ms. Yelverton feels very fortunate, also, to work with many other teachers that share her desire to "step outside the boundaries" and with an administration that has confidence in the faculty.

Action research has helped to crystallize a confidence within Ms. Yelverton that she is capable of recognizing what is important for her students, that students will be able to access information if they learn the skills. Although she may not say this herself, she now recognizes her own expertise. She is much more relaxed about experimenting with new projects and using alternative assessment methods. One alternative form of assessment that she has used this year is to allow the students to set their own criteria for grading various assignments. She has found that the students are very capable of recognizing quality work and set very high standards for themselves.

The nature trail continues to flourish. The local garden club helped the students add a butterfly garden, birdfeeders and a frog pond. The students have formed their own garden club. With all the new flora and fauna, the reference book will soon need an update, creating yet another opportunity for an authentic learning experience.

Jane B. McDonald

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Footnotes

1 The choice of ten as the number of specimens was based on what I assumed to be a reasonable sample size.

2 ExploraVision is associated with Toshiba and links students as working partners with engineers and businesses to develop futuristic inventions.

3 The Florida EXPLORES! program is an educational outreach program of the Florida State University Meteorology Department that implements direct-readouts satellite ground stations into K-12 classrooms.

4 Project CHILD, Computers Helping in Learning Development, is a worldwide educational program.

CHAPTER THREE

Changing a Teacher's Role to Evoke Meaningful Learning Behaviors

Paul M. Veldman

Abstract

The effect of facilitative teaching on student learning was investigated through 16 videotaped lessons. A model of a facilitator portraying three roles: coach, consultant, and counselor, was adopted for this study. The coach introduces the unit, gives advice and encouragement, and provides feedback. The consultant clarifies details and initiates discussions of student problems. The counselor provides patience and understanding in a non-threatening environment (Keenan & Braxton-Brown, 1991). As a result of this facilitation the students are able to demonstrate 5 student learning behaviors: analysis of a problem, questioning the analysis, developing and testing a hypothesis, comparing ideas with peers and supporting their hypothesis or constructing new meaning.

I thought I was the kind of teacher that allowed my students to analyze a problem, question their analyses, develop and test hypotheses, compare ideas with those of other students, and support their hypotheses or construct new meanings, student behaviors similar to those suggested by Livdahl (1991)[1]. Teachers who facilitate learning as part of their teaching style find these meaningful learning approaches occurring in their classrooms (Kember & Gow, 1994).

Keenan & Braxton-Brown (1991) describe the roles of a facilitator as a coach, consultant, and counselor[2]. The coach introduces the unit, gives encouragement and advice as necessary, and provides feedback, response, or both to the students. The consultant clarifies details and initiates discussions of problems that students encounter, and the counselor provides patience and understanding in a non-threatening environment. I was very interested in examining how I acted as a facilitator of learning, using these roles as a model.

Prior to doing this study, I videotaped myself while teaching fifteen science lessons and then viewed the tapes to analyze my teaching style. While watching the videotapes, I asked the question, "Who's doing all the talking?", and I realized it was *me*! I realized that I led the students to the answers I wanted to

hear—that, contrary to what I thought, I was a director of student learning rather than a facilitator. A director leads the students to predetermined outcomes, whereas a facilitator presents learning opportunities to students who in turn discover the outcomes themselves.

For example, one lesson I analyzed was about continental drift. I chose this lesson to analyze because I felt it was my worst lesson. I had set up an activity for my students to discover the expansion of the Atlantic Ocean through a hands-on map manipulation. The students worked in pairs and cut the continents out of a map. I directed the students to place the continents on their desks in the correct global positions and then described how to move the map pieces to simulate the drift of the continents. I concluded the activity without ever allowing the students to discover the theory of continental drift or to share their ideas or to ask questions. Upon viewing the videotape I realized I was directing all of the activities, picking and choosing what I wanted to hear from my students and when I wanted to hear it. I elicited none of those behaviors that resulted in deep, meaningful learning! Yet, Lowery (1989) contends that the teacher should be a manager of learning rather than a provider of information. Jaeger & Lauritzen (1992) explain, "No amount of teacher talk facilitates conceptual change" (p. 13).

I wanted my students to learn more independently than my "director" role allowed. My hypothesis was that, if I changed my teaching style from that of director to facilitator, I would be able to evoke these learning behaviors that encouraged the students to discover the outcomes themselves and become life-long learners.

Method

I selected a group of five fifth grade students from my ESE inclusion class[3] to use as my test group. This group was chosen because it was comprised of three boys and two girls who ranged in age from ten to twelve and were of varying ability. Two had specific learning disabilities. I met with the group for forty minutes each day, four days a week, while the remainder of the class, also in groups, participated in different academic activities.

For this study, I once again videotaped myself while teaching 16 sessions of lessons on magnets and motors. I decided that my role in teaching these lessons was to facilitate the students' activities by introducing each lesson, by encouraging as necessary, by providing feedback and response, and by not setting limits on pathways to the outcomes. The unit, supplied by the National Science Resource Center's *Science and Technology for Children* (1992), contained lessons which ranged in topics from "What Can Magnets Do?" to "Creating Magnetism through Electricity" to "Making a Motor" to "Generating Electricity." Each lesson provided the students the opportunity to do hands-on experiments that encouraged them to explore new ideas and expand their knowledge about magnets and motors.

After viewing all of the videotapes, I selected five sessions which covered a variety of topics and procedures to analyze. In the first two sessions, the students individually conducted similar experiments and then shared their discoveries with the group. In one, they examined the properties of magnets, and, in the other, the magnetic properties of other objects. In the third session, the group divided into two teams: Team 1 was comprised of three students; Team 2 was comprised of two students. Each team conducted tests to determine if additional magnets affected magnetic strength. In the fourth, the five students worked as one group to identify the various parts of an electromagnet and designed an experiment to increase the strength of the electromagnet. The final videotaped session showed the students conducting this experiment.

"While watching the videotapes, I asked the question, 'Who's doing all the talking?', and I realized it was me!"

"A director leads the students to predetermined outcomes, whereas a facilitator presents learning opportunities to students who in turn discover the outcomes themselves."

To determine if teacher facilitation affected student learning behaviors, I first needed to determine if I was actually facilitating; I needed to analyze my teaching style. So I devised a checklist (Appendix A) to ascertain if I fulfilled the roles of coach, consultant,

"I simply initiated the discussion, and the students resolved the problem."

and counselor during these lessons. I viewed the videotapes and tallied the number of times I observed myself exhibiting a behavior that fulfilled each role. I also wrote additional comments.

I viewed the tapes a second time to observe student learning behaviors. The five behaviors I tallied were: analyzing the problem, questioning the analysis, developing and testing a hypothesis, comparing ideas with peers, and supporting the hypothesis or constructing a new meaning (Appendix B). I also indicated if a student was off-task, and I again wrote additional comments.

To determine if learning had occurred, I compared the results of a pre-unit and a post-unit assessment of the topic. I administered the following questions before and after the unit: "(1) Think of all the places that electricity comes from. Make a list of at least five of those places below. (2) Draw a picture of what you think an electric motor looks like. Please put labels on your drawing in order to tell other people about it"(National Science Resources Center, 1992).

Observations

Before each lesson, I reviewed the topic only by asking the students to reflect on concepts learned the previous day or on prior knowledge of the subject. Then, as a coach, I introduced each lesson by indicating what we would be studying during that time, but I did not tell them what they would discover. I did not direct their learning; I tried only to motivate their desire to discover on their own[4].

An example of coaching behavior surfaced in the lesson in which students tested the strength of the electromagnet they had designed. When the electromagnet did not work after the addition of a second battery the students immediately assumed their hypothesis was wrong. Although they could not understand why this would be, they did not even think to question their procedure. So I, acting as a coach, suggested that they check the batteries[5]. After listening to this advice, they discovered that the batteries were incorrectly connected. They rewired them and were excited to discover that their hypothesis was correct after all. I had facilitated the type of learning experience in which the teacher is called upon only when needed to help remedy a student misunderstanding (Hudson-Ross, 1989). This, a "teachable moment," could not have been planned and directed. I repeatedly observed that giving encouragement and advice to the students as needed was a key factor in the facilitative teaching environment. It propelled the students to experiment, to find answers on their own or with the help of their teammates, and it encouraged them to open up and share ideas.

The role of a coach is also to provide feedback, which I typically did at the end of each lesson. For example, in one lesson, the students predicted the magnetic properties of various objects prior to doing the experiment. Naomi[6] found that a brass washer was attracted by a magnet and, in our concluding group discussion, expressed her surprise. The other students, when encouraged by me as a coach, compared their results and found them to differ. Then Naomi retested the washer and found her first result to be incorrect. Feedback, not only from myself but also from her team members, allowed clarification of this. Thus, by providing only a little

feedback rather than an answer, I had given my students an opportunity for the learning that Jaeger & Lauritzen (1992) describe: "Learners are supple to the leading of other learners and will often modify or adopt a new construct invented as a collective effort more readily than if offered as a distant truth" (p. 11).

One of the consultant roles, that of clarifying details, emerged predominantly at the beginning of each lesson. In one lesson, for example, the students identified the variables of an electromagnet and selected a variable that, if changed, would increase the electromagnet's strength. However, the students as a group were able to identify the variables only after I had defined the meaning of "variable" and thus acted as a consultant.

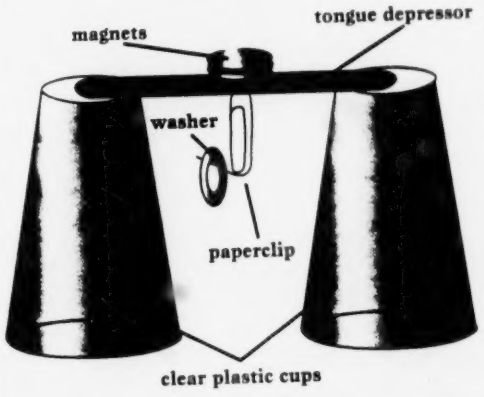
I acted as a consultant throughout the lessons as the students encountered problems. This role often ran hand-in-hand with the coach's trait of giving encouragement and advice. However, in order to facilitate, I did not give advice when acting as a consultant. I simply initiated the discussion, and the students resolved the problem.

One experiment the students conducted was to determine the strength of different combinations of magnets. They were given four magnets, a tongue depressor, two plastic cups, steel washers, and a paper clip. Turning the cups upside down, the students then made a bridge with the tongue depressor and placed a magnet on top of the tongue depressor with a bent paper clip that could hold washers underneath the tongue depressor (see Figure 1). Their task was to add washers to the paper clip and to record the number of washers that one, two, three, and four magnets would hold.

Keshia, a member of Team 2, hypothesized that additional magnets would cancel the magnetic properties of the first magnet, whereas Adam, her teammate, and the students on Team 1 thought that additional ones would strengthen it. How hard it was for me not to correct her! But I did not—I allowed the students to experiment and teach themselves.

The results of the experiment for Team 1 showed that a combination of four magnets held fewer paper clips than a combination of two or three. Charlie, one of the Team 1 members, questioned these data. As a facilitator, I asked him what he should do, and he responded, "Retest because four magnets should hold more than two or three." As a result of his questioning, the team retested and discovered Charlie's analysis was right. During the process, the teammates compared ideas with one another as well as charted their results. At the conclusion of the lesson, they compared data with the other team. Team 1 discovered that one magnet held three washers, two held seven, three held ten, and four held ten. Team 2 found that one held three, two held six, three held nine,

Figure 1
Setup for Determining the Strength of Different Combinations of Magnets

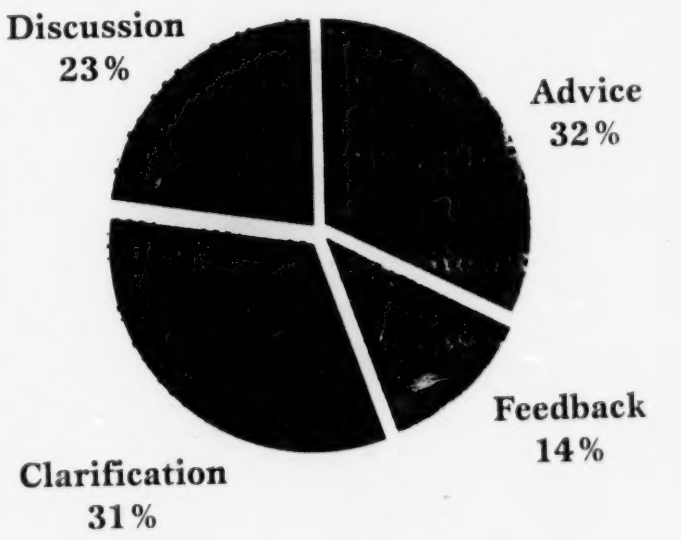


and four held ten. Their surprise at the similarity of the results led to a discussion of fair testing, experiments in which all variables are held constant except the one being investigated. This type of learning experience took more time, but it allowed Keshia to construct a new concept while the other students confirmed their original hypotheses. My students had exhibited collaborative learning in which the students learn from and listen to other students (Lardner, 1989).

Also during this experiment, functioning in the role of consultant, I casually remarked that they would need nimble fingers to put the washers on the dangling paper clip. In response to this, Team 1, who had seen a pattern developing, decided to estimate the number of washers that three and four magnets would hold and put the washers on the paper clip before attaching the paper clip to the magnet. My students had became empowered learners! They had developed an understanding of the magnetic properties and had devised a more efficient way to conduct the tests all on their own (Brown, 1992), something I did not observe in students when I had acted as a "director" of student learning.

Figure 2
Incidence of Facilitator Behaviors

Percentages of incidents of teacher facilitated behaviors tallied during observations of lessons



Results

Was I Facilitating?

I found myself in the various roles of a teacher facilitator throughout each lesson. The procedure for each lesson was similar. I introduced the lesson and included a review of previous learning. The students held discussions among themselves and with me. Next the students manipulated the materials which allowed them to test and build their own hypotheses. Each day we concluded with sharing the results of the day's activity and the students' new or reinforced concepts.

I tallied each of the five behaviors a facilitator uses in the roles of coach and consultant. I introduced the lesson only once, at the beginning of each daily lesson. The other four behaviors, the coach giving (a) advice and (b) feedback, and the consultant (a) clarifying details and (b) initiating discussions, were seen throughout each lesson. Thirty-two percent of my facilitative behaviors were directed at giving the students encouragement and advice. I clarified details 31 percent of the time. Twenty-three percent of the time I initiated discussions of problems that the students faced, and 14 percent of the time I provided feedback, response, or both (see Figure 2). I acted as a counselor throughout each lesson by being patient and understanding.

Were the Students "Learning"?

The responses to the first pre-unit question, "Think of all the places that electricity comes from," ranged in answer from "I don't know," to "lightning," to "the wall socket." The post-unit response to the same question by all of the students included "generators."

The drawings of motors for the second pre-unit question were unrecognizable and unlabeled (see Figure 3). In the post-unit assessment, the students not only drew an accurate picture of a motor but also labeled its components (see Figure 4). These assessments indicated to me that the students had constructed new meanings and "learned".

Figure 3
Pre-Unit Drawing of a Motor

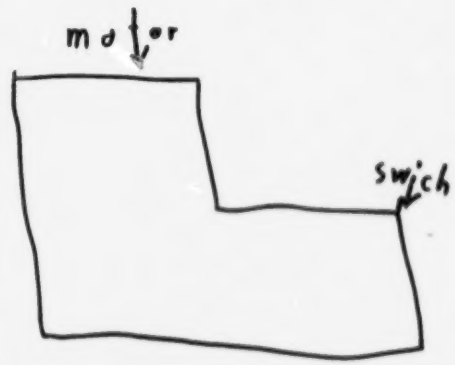
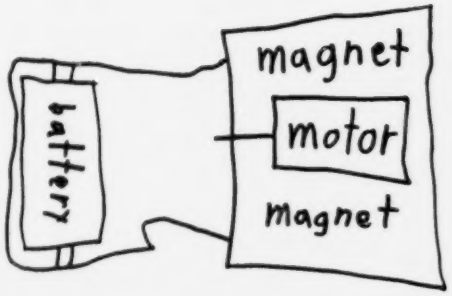


Figure 4
Post-Unit Drawing of a Motor



Did They Exhibit the Meaningful Learning Behaviors?
Each student demonstrated all five of these behaviors in each lesson: the students analyzed the problem, questioned their analysis, developed and tested their hypothesis, compared ideas with peers, and supported their hypothesis or constructed new meanings.

Conclusion

The results of this study show that when I changed my teaching style from that of director to facilitator, the students correspondingly changed and exhibited positive learning behaviors. What I saw was that, not only did my students learn, as evidenced in the unit pre- and post-assessments, but they also enjoyed the lessons, stayed on task and were highly motivated to learn.

By no means am I implying that students can only exhibit learning behaviors when a teacher is a facilitator. I believe that the most important factor is that the teacher identify his or her learning behaviors and then implement a teaching method that is effective both for the teacher and his or her students.

This research process benefited both me and my students. In retrospect, I see that my research does not necessarily include all the components of scientific research. If I were to do this research again, I would tally director behaviors, as well as facilitator behaviors. Alternatively, I would consider analyzing the amount of time the students spend exhibiting positive learning behavior in response to an incident of either director or facilitator style teaching. Nevertheless, I learned so much from this research, in the same way that my students learned when I became a facilitator. I was not directed through my research. Instead, I learned how to do research by doing it. ❖

"Not only did my students learn... but they also enjoyed the lessons, stayed on task, and were highly motivated to learn."

Epilogue

by Jane B. McDonald, Editor

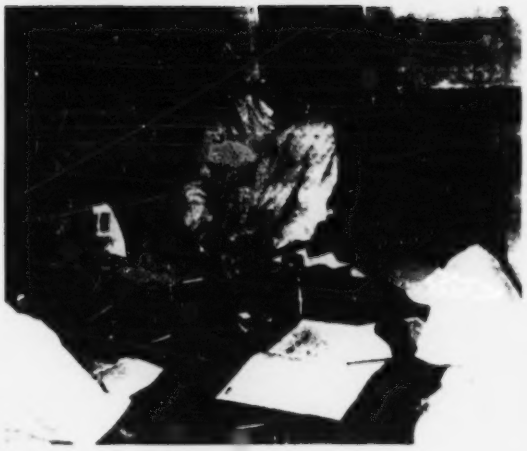
A year later, Mr. Veldman is still excited about how this action research project had an impact upon his teaching methods

and his perspective. He says, "I never would have videotaped myself on my own initiative. I would have maintained the status quo, believing I was teaching my students to think yet actually simply taking students through pre-defined motions."

Enthusiasm exudes from him as he describes the interest for science that he saw in his students when he implemented teacher facilitation. This was so successful an endeavor that the principal in his school requested one of his groups to present a 15 minute demonstration of one of the lessons to the faculty. A low-ability student organized and led the presentation. Mr. Veldman was thrilled that, not only had he become more of the teacher that he wanted to be, but his supposedly "low-level" students had learned much about magnets and motors plus had become enthusiastic and empowered learners.

Mr. Veldman has relocated to another city to be closer to his family. He and his wife now teach in a school with more rigorously defined protocol, and Mr. Veldman has fewer opportunities and materials with which to continue his non-directive approach in science. He is a part of a "directed reading" program which has a set curriculum and teaching method. His action research, however, continues to flavor his teaching, and he offers as many facilitated learning situations as he can. For example, although the reading program is very structured, he also incorporates role-playing as an open-ended assignment.

Jane B. McDonald



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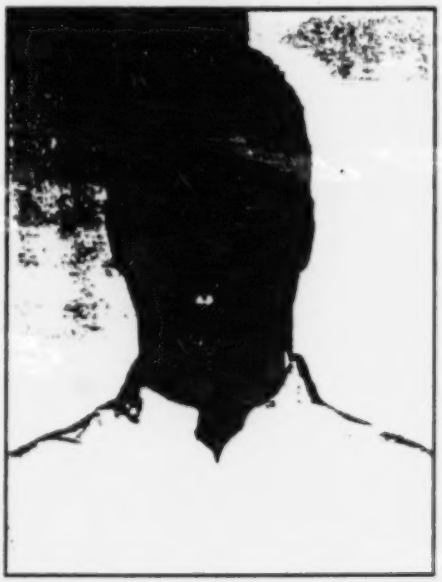

Paul M. Veldman

Years Teaching: 8

Present Position: 4th and 5th Combination Teacher

I had never considered teaching until I did a little coaching and umping of Little League. I enjoyed working with the kids. Something interesting was happening every day.

Go into action research with an open mind and expect to see things about yourself. Everyone should videotape themselves teaching. As you watch you think, 'I did this? Why did I do that?' Getting started is the hardest. But remember, a journey begins with one step.

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Footnotes

1 My student learning behaviors are similar to Livdahl's with the following exception: I believe that first the students need to analyze the situation and then to question their analysis. This analysis helps the students form a clear picture of the problem in which they will engage. The students then develop and test hypotheses and share their results with other students. From analyzing, testing, and sharing, the students can then either support their original hypotheses or construct new meanings.

2 Keenan and Braxton-Brown also include the role of the critic. I have omitted the role of critic because I feel that the role of the critic is dispersed throughout the other three roles.

3 ESE stands for exceptional student education. Inclusion means that students with disabilities are in general education classes and participate in regular extracurricular activities.

4 As I frequently tell my students, I cannot educate unmotivated students (Kember & Gow, 1994).

5 Keenan and Braxton-Brown (1991) support that suggestions are necessary because the student does not have a full understanding of the problem.

6 All names are fictitious.

Appendix A

Checklist
Teacher Facilitator

Lesson # _____

I. COACH

Behavior	Times Observed
Introduces unit	
Gives encouragement and advice	
Provides feedback	

Notes:

II. CONSULTANT

Behavior	Times Observed
Clarifies details	
Initiates discussions of problems that students face	

Notes:

III. COUNSELOR

Behavior	Times Observed
Provides patience and understanding in a non-threatening environment	

Notes:

Appendix B

Checklist
Student Learning Behaviors

Lesson # _____

I. ANALYZE PROBLEM

Student					
Times observed					

Notes:

II. QUESTION THE ANSWERS

Student					
Times observed					

Notes:

III. DEVELOP AND TEST A HYPOTHESIS

Student					
Times observed					

Notes:

IV. COMPARE IDEAS WITH PEERS

Student					
Times observed					

Notes:

V. SUPPORT HIS/HER HYPOTHESIS OR CONSTRUCT A NEW MEANING

Student					
Times observed					

Notes:

CHAPTER FOUR

Does Student Responsibility for Learning Increase When Students Ask and Answer Their Own Problem-Solving Questions?

Toni B. Haydon

Abstract

Students were repeatedly presented with simple problems or materials and asked to form questions that could be answered through scientific experimentation, and they were asked to create an experiment with a prediction, materials list, procedure, data chart, results, and conclusion. Results indicated that students maintained the level of responsibility they had upon entering the class. However, an anecdotal postscript describes post-study activities which suggest progress in the students' levels of responsibility, creativity, enthusiasm, and confidence.

The purpose of my study was to determine if student responsibility is increased when students ask and find the answer to their own problem solving questions. I believe that, as Schank (1988) described, if students are presented new concepts in exploratory situations, the questions they ask and the procedures they develop to answer their questions should help them become more active in their own learning process.

For this study, I define responsibility as (a) initiating an idea for a task by formulating one's own question about a challenge (problem or event); and (b) completing a laboratory report which includes a written question—either one's own question or one from another source, a prediction, a materials list, a written procedure, data charts, results and a conclusion.

Background

To formulate one's own question is to decide what one is to learn and this naturally places the burden of responsibility for learning upon oneself. Formulating a question about a problem or event requires creativity. Thus, becoming more responsible, according to the definition I have used for responsibility in this study, requires creativity. The problem with learning to be creative or to ask questions is that it is possible to fail.

Schools either teach children to avoid failure, or they set up a system in which it is impossible to fail (Schank, 1988). Children establish patterns in their years of schooling. So they must relearn what was once natural and unlearn what our social system and our school systems have taught them (Schank, 1988).

Failure can be beneficial. It can motivate one to succeed, as Schank (1988) describes, "The process of failing and then recovering from that failure can be the source of the creative spark"(p. 59). Temporarily failing can lead to thinking about what went wrong. "By teaching kids and adults to overcome their fear of failure, we can show them how to overtake the risk of doing or just thinking something wild and having it not work out. That is the only way they will stand a chance of coming up with something new and creative that *does* work out" (Schank, p. 61).

Schools are partly responsible for closing the avenue to creativity because the system tends to applaud success and instill the fear of failure. The procedure I designed for helping students to learn to become responsible for their own learning collided head on with everything these students had learned since their kindergarten years.

Method

Setting

This research was conducted in a sixth grade class at a university research K-12 school. The population of students represents the state's economic and racial composition. These classes were conducted in a traditional classroom with no science facilities. The gifted students had been selected out so that the classes were a heterogeneous mix of average to below average students. The ten students selected for my study were chosen from the class roster before I met them and were based on race and sex.

Data Collection

For this study I defined the word "section" to represent both the formulation of a question by a student and the various parts of a written laboratory report. These parts, or "sections" of the written report were a written question, regardless of the source; a prediction of the answer to the question; a list of materials; a written procedure; data charts with titles; results; and a conclusion.

I used two methods of data collection:

1. **Observation:** I noted the students attitudes as they began each activity, whether an investigation, project, or examination, and I recorded their comments as they worked. If the student formulated his or her own question I considered this as a "section" successfully completed and recorded it as such.

2. **Document Analysis:** I collected each laboratory report and tallied which "sections" of the written report each student satisfactorily completed.

General Lesson Plans

At the beginning of the year, I made very specific, detailed lesson plans for the first two nine-week sessions. During the first nine weeks I planned to present four investigations to the students. With each investigation, I increased the number of sections (Table 1, page 52) for which the students would be responsible. I explained each section initially and helped the students as necessary, but I decreased my input as the semester progressed to allow them to become increasingly more responsible for their own performance.

The main emphasis during the second nine weeks was the Science Fair project. Most of the work was done at school. All sections were required for the Science Fair project. Before the due date of the project, we completed three short investigations designed to refresh the students' memories about data charts, graphing, and probability.

The semester examination was in the form of a laboratory investigation, and included all sections.

The First Nine Weeks

Investigation 1: Picking up a chair.
On the first day of school, I challenged each of the students to pick up a kindergarten size chair while they kept their heels and bottoms in contact with the wall. Before experimentation could begin, the students needed to recognize a problem and ask a question that could be investigated. Consequently, on the second day I helped the students to realize that a "Problem" existed: The chair could not be picked up by everyone. I wrote this problem on the board and asked the students if they could think of any questions that might lead us to the resolution of this problem. Some examples included the following:

- Why could only two girls out of fifty students pick up the chair?
- Is the chair too close to the wall to be picked up?
- Is the chair too far away?
- Does the shape of the person's body have anything to do with the ability to pick up the chair?

We listed these questions and discussed what a prediction is and then recorded two predictions for each question on the board. I emphasized that a prediction must relate to the question being asked. It can be right or wrong. I also mentioned that sometimes finding an answer that differs from the prediction can lead to more knowledge than was expected or can lead to a new question.

For the next three investigations, I simply supplied the students with laboratory materials and asked them to formulate their own question. I developed the concepts of each section for which they were responsible, as appropriate.

Investigation 2: Tea and baking soda.
I supplied the students with two baby food jars, lemon juice, baking soda, hot tea, stirring rods, teaspoons, and a paper towel. I

asked them to look at the materials and to try to come up with a question about what they wanted to learn about these materials. To get the students beyond their prior experiences, I suggested that we already knew about the "volcano" effect of baking soda and lemon juice, and that they might incorporate the tea into their question. I knew that color changes occur when lemon juice or baking soda is added to tea , but I did not tell the students.

At first, the students were silent! Then they pleaded with me for fifteen minutes to tell them the question they were "supposed" to ask! Finally, I told them to formulate any question as long as it incorporated *all* of the materials, and I allowed them to share questions. But I emphasized that I preferred each person or group (depending on how they were working) to come up with their very own question, because then they would be discovering something of interest to themselves.

The students wrote individual laboratory reports that included the written question, the procedure, and data recorded in charts. I explained that the materials lists and procedures are written so that someone else can repeat the experiment. I taught them how to make data charts, enclosing them with borders and providing titles that indicate the content of the chart and subtitles with information about quantities or the quality of the data collected.

As a class we discussed the difference between results and conclusions: results are data in paragraph form; the conclusion is an explanation of why the investigator thinks these results occurred. We listed the results of the various experiments and formulated possible conclusions. The students then wrote their own results and conclusion sections in their reports.

"At first, the students were silent! Then they pleaded with me for fifteen minutes to tell them the question they were 'supposed' to ask!"

Investigation 3: Air pressure.
The next set of materials consisted of two, 2-liter plastic bottles, two rubber bands, a balloon, scissors, and one dish pan. Also available were boiling water and crushed ice. The assignment was to work in pairs and to discuss with each other what they wanted to learn about the set of materials. The students spent an entire hour-long class discussing this. They also again pleaded repeatedly for a hint about what "I wanted them to find out." But I reminded them to think about what they had learned in their former science classes and about what they wanted to learn right now. The next day some pairs of students began formulating questions.

I walked around, initialed their questions and told them to write a prediction, a procedure and a materials list, and to construct a data chart. "What's the first step in the procedure?" was a common question. I would not answer that question because, as I explained to the students, many of them had posed different questions. Instead, I facilitated the writing of the procedure by reminding them to think of the steps they would need to take to answer their questions. I told them to relax and to think about what needed to be done. Before the students conducted their experiment, I read their reports and wrote comments to help them clarify procedural steps and to design more appropriate data charts.

When all the students had concluded their experiments, we discussed our results. We also viewed a physics videotape that dealt with temperature in relationship to air pressure. The students had viewed this tape in previous science classes, and their teacher had demonstrated an experiment similar to the ones they had developed. As they viewed the tape they began commenting on information they were gathering that would help them form the conclusions to their experiments.

Investigation 4: Volume of a rock.
The students had previously learned to calculate the volume of cubes. Thus, for this investigation, each pair of students received three rocks, a wooden block (a cube), a metric ruler, a 1000 ml beaker, a 250 ml beaker, a 50 ml graduated cylinder, and a dishpan full of water. They were instructed to find the volume of each rock and prove that their method worked.

Most of the students formulated and wrote their questions that day and listed their materials. I dropped hints about calculating the volume of cubes. They "played" with the materials and discussed possible procedures for the investigation. The investigations were completed within a few days. The students were required to complete all sections of the laboratory report.

The Second Nine Weeks

The Science Fair project.
Each student was required to think of three questions of interest to him/her for a Science Fair project. If any student could not do this, I provided a list of ideas. Each narrowed the questions down to one with my help.

The students were required to write a five-page paper and conduct an interview with a person who had information pertaining to their question. For one week they obtained information resources from the library. They

spent two weeks in class jotting down notes of information from the resources and then wrote rough drafts of their papers in class. They also used class time to call and conduct or set up interviews. I made grammatical corrections on rough drafts of their papers.

The students designed and conducted investigations in class and wrote laboratory reports that I checked for accuracy and form. They were required to finish their experiments and collect data during the winter break.

I collected the data charts, graphs, results, and conclusions for the Science Fair project from each student so that I could review and return them in time for the students to finalize their reports and prepare their displays for the Science Fair. During this time we also completed three short investigations to help the students manipulate their data correctly. They received a handout describing the required Science Fair display so they could begin thinking about the organization of their boards.

Investigation 5: Measuring leaves.
The students each collected and measured the length of ten leaves. They recorded the data on the board and in their own data charts, created their own questions, wrote laboratory reports, and constructed graphs.

Investigation 6: Picking up paper clips.
For this investigation, I informed the students verbally of the procedure: "You will spread 20 paper clips on the table in front of you and close your eyes. I will say, 'Go.' You will have 15 seconds to pick up the paper clips between your thumb and forefinger and

place the clips in the Petri dish. You may only pick up one paper clip at a time. We will do this three times. You will record the data after each trial."

Before we began, the students were required to write a question, a prediction, a materials list, a procedure, and to construct a data chart. They accomplished this and collected and recorded data on the same day. The following day the students constructed bar or line graphs and wrote up the results and conclusions. We discussed the results, conclusions, and graphs after I collected the papers.

Investigation 7: Probability.
The students were asked to construct a spinner, divide it into eighths, and color it so that 2/8 were red, 2/8 were blue, 3/8 were yellow, and 1/8 was green (see Figure 1). They were to spin the spinner 100 times and record the number of times the spinner landed on each color. They formulated questions, made predictions, wrote a materials list and a procedure, made data charts, and then constructed the spinners. They collected data, graphed it, and wrote the results and conclusion sections of the laboratory reports, which I collected.

The Semester Examination

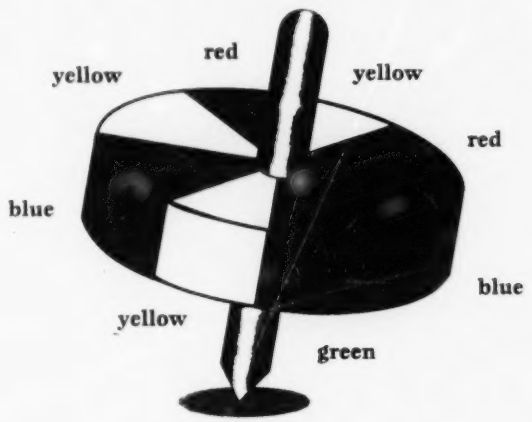
For the semester examination, I gave each student one *Lifesaver* candy. I instructed them only to suck the *Lifesaver*, not to chew it. They put the *Lifesavers* in their mouths at the same time and were told to raise their hand when their *Lifesaver* had completely dissolved. I recorded the starting time and ending times on the board. The students were told to formulate their own questions and to write up a complete laboratory report, which was to include a graph. Semester examinations are two hours long.

Results

A few students complained that the method of coming up with your own question was too hard. My typical reply was, "Yes, this work is harder than just following the laboratory directions in the book, but this will help you to learn to think and make decisions." When one student asked, "When are we just going to use the book and answer questions at the end of the chapters? That's the way I learn," I replied that we would do that sometimes, but if that was what she needed in order to learn then she could always do the questions and answers on her own time. She never attempted this.

Table 1 indicates the total number of sections of each part of the investigations that each student completed.

Figure 1
Example of a Spinner



Lou[1], who initiated no questions, was frustrated with this type of activity. Each time I introduced an investigation, Lou would lay back in his chair, roll his eyes, and wrinkle his face in such a way that showed he was already defeated. What sections he did complete were copied from other students. Possibly Lou completed more work on his Science Fair project (Table 2) because he had help at home, and it comprised the majority of the grade for the second nine weeks. His failure to do any part of the final examination (Table 3) indicated to me that he still could not formalize any of the work because of his frustration level.

Sam made comments such as, "This is fun!" or, "Wow! We get to do anything we want with these materials!" Although Sam was absent frequently, he did all of the work, except one conclusion.

Table 1

Results of Students' Completion of Investigations

Section of Project	Total	Total of Sections Successfully Completed: Student									
		Lou	Sam	Tom	Bob	Mark	Kate	Sue	Amy	Kay	Lori
OBSERVATIONS											
Formulates own question	7	0	3	1	2	3	1	6	2	0	1
DOCUMENT ANALYSIS											
Written question	7	3	3	2	3	3	3	6	6	1	1
Prediction	7	3	3	3	3	5	3	6	6	0	3
Materials List	7	3	3	3	3	5	3	6	6	0	1
Procedure	7	3	3	1	1	5	3	6	6	0	3
Data Charts	7	1	3	1	2	4	1	4	6	1	3
Results	6	1	2	0	0	4	1	4	4	0	0
Conclusion	6	1	2	0	1	4	2	3	4	0	0

Tom attempted parts of the first three investigations but did not do any of the others. Although capable of doing the work, Tom constantly complained that it was just too hard. One day, however, to my surprise and that of the entire class, Tom was the first student to create his own question, prediction, materials list, and procedure. He proclaimed, "This is so easy! I can do it now!" I publicly congratulated him and said he was now on his way to success. But then he did not turn in his work! Tom was very immature in his work habits. In fact, Tom's father requested periodic conferences to ensure Tom completed all assignments. Thus, with the help of his father, Tom finished his Science Fair Project. Tom's failure to complete all sections of the final examination was due to lack of time.

Bob, more immature in his work habits and his personality than Tom, would cry when

Table 2

Results of Students' Completion of Science Fair Project

Section of Project	Section Completed — Student									
	Lou	Sam	Tom	Bob	Mark	Kate	Sue	Amy	Kay	Lori
OBSERVATIONS										
Formulates own question	0	+	0	0	0	+	+	+	0	0
DOCUMENT ANALYSIS										
Written question	+	+	+	0	+	0	+	+	0	+
Prediction	+	+	+	0	+	0	+	+	0	+
Materials List	+	+	+	0	+	0	+	+	0	+
Procedure	+	+	+	0	+	0	+	+	0	+
Data Charts	0	+	+	0	0	0	+	+	0	+
Results	+	+	+	0	0	0	+	+	0	+
Conclusion	+	+	+	0	0	0	+	+	0	+

NOTE: + = section satisfactorily completed
0 = section either not submitted or completed unsatisfactorily

Table 3

Results of Students' Completion of Semester Examination

Section of Examination	Section Completed: Student									
	Lou	Sam	Tom	Bob	Mark	Kate	Sue	Amy	Kay	Lori
OBSERVATIONS										
Formulates own question	0	+	+	+	+	+	+	+	+	+
DOCUMENT ANALYSIS										
Written question	0	+	+	+	+	+	+	+	+	+
Prediction	0	+	+	+	+	+	+	+	+	+
Materials List	0	+	+	+	+	+	+	+	+	0
Procedure	0	+	+	+	+	+	+	+	+	+
Data Charts	0	+	0	+	+	+	0	+	+	0
Results	0	+	0	+	+	+	0	+	+	0
Conclusion	+	+	+	0	0	0	+	+	+	+

NOTE: + = section satisfactorily completed
0 = section either not submitted or completed unsatisfactorily

he could think of no question. Often he put his head down until someone else started working on an investigation. He then would watch and occasionally participate.

Mark, who completed much of the work, did not successfully complete his Science Fair project because he had difficulty making one of the substances he needed to successfully carry out his experiment. Because of the lack of data, he did not include results or conclusions in his project.

Kate was very social. She seemed to enjoy being able to share ideas rather than develop her own questions. She formulated only one question of her own. She often ran out of time due to her social interactions and submitted only three investigations. Although I suggested that she finish her work at home,

she did not. Kate probably would have completed more of her Science Fair project had she not become so involved in attempting to contact and interview someone.

Sue consistently completed not only the written portions of the investigations, Science Fair project, and semester examination and she also initiated work in the form of formulating her own questions. Incomplete work was due to absences and, on the semester examination, lack of time because of her desire to be careful and neat.

Amy was always conscientious about her work and completed almost all assignments. One investigation was not completed due to absences. However, Amy initiated only two questions out of the seven investigations. Twice she chose to use a partner's question rather than create her own. I knew Amy had the ability to formulate a question, but she was not used to making decisions. Occasionally she would cry when she could not think of a question. I told her to be calm and just sit and think and gave her subtle suggestions to stimulate her thought processes, but I never provided her with a question.

Kay had very low skills for sixth grade. She sat and watched the other members of her various groups and occasionally attempted to write parts of the investigations. The only lab report that she submitted was near the end of the semester, and then it included only the question and data. The Science Fair project was extremely difficult for Kay even though I worked with her, as I did all students, to help her clarify her procedure and lab report. I also stressed that what we did everyday was more important than the final product. Even so, she still somehow felt incompetent and did not submit anything. She never told me why as other students had. Although Kay had shown little progress during the semester, she completed all sections of her semester examination.

Lori needed a lot of attention from me and her parents before she felt any incentive to do assignments. She was in my larger science class and I did not recognize this need until we began the Science Fair projects. Before this she worked sporadically during class. After I had a conference with Lori and her parents she then began to work eagerly. After the conference I made it a point to speak to her daily about her project. She did all parts of the Science Fair project except initiating the question. Lori did not complete the materials list, data charts, or results section of her semester exam. She was also still weak at writing a procedure and conclusion without some support. Lori initiated only one question other than the semester examination question.

I was very disheartened by the results of the Science Fair project as shown in Table 2. I felt as if my students were not accepting the challenge to become responsible for their own learning by formulating their own questions and writing their own laboratory investigations.

Students still approached me during the semester examination for help in finding out what question I wanted them to ask, but fewer than at the beginning of the semester. During the second period exam, I found myself still attempting to help students formulate my question: Do boys or girls dissolve the *Lifesaver* faster? I was limiting their knowledge! I became uncomfortable when I realized I was doing this. Consequently, during the next class, I did not influence the formation of anyone's question and the results were wonderful. This class had a greater variety of questions than the second period class: Will the green *Lifesavers* dissolve faster than the red ones? Which color *Lifesaver* dissolved the fastest? Does the way the *Lifesaver* is sucked affect how fast it dissolves? Does the amount of saliva in a person's mouth affect the speed that the *Lifesaver* dissolves?

Conclusion

The results for the investigations portion of this study (Table 1) showed various levels of responsibility as defined by the students formulating a question and completing sections of the laboratory report . For the Science Fair (Table 2), most of the students were as responsible in doing their projects as they were with their investigations, or less responsible. Most sections of the semester examination were completed by most students. The exception was Lou, who wrote only a conclusion. All students but Lou formulated their own question for the semester examination (Table 3). Overall, I expected a much greater increase in the responsibility of my students than the results indicate.

"Patterns are very difficult to change with one semester of work. Some students...were willing to take risks....Others, so ingrained with the fear of failure, could not overcome their fear in one semester."

I believe that these results were due to the patterns that children have established in their previous years of school. Patterns are very difficult to change in just one semester of work. Some students in this study were willing to ask questions, take risks, and assume responsibility for their own learning before they even entered my class. Others, so ingrained with the fear of failure, could not overcome their fear in one semester.

This study also included a definition of responsibility for learning that was mine, not the definition that belonged to each student. Individual interviews would have yielded insight into the students' definitions of responsibility of learning. Interviews would also have helped in determining why the students did not complete various parts of the experiments or why, as in Lou's case, he did not attempt any of the work on his own.

The Science Fair project results discouraged me. What I saw was a lack of growth in responsibility. The results of the semester examination, nevertheless, were encouraging. At the beginning of this research it was common for the students to spend up to two hours trying to think of a question and a week to conduct an investigation. Thus, being able to complete a laboratory investigation and write it up as an examination in a

two hour period was an accomplishment in itself. The results also indicated that all but Lou had learned the skills of conducting an investigation and writing a laboratory report, regardless of having used them previously.

The formulation of the question was, from my observations, the most important step in every activity we did—the investigations, the Science Fair projects, and the semester examination. Unless a question was written down, no further work could be accomplished. Also, the formulation of a question revealed curiosity and responsibility on the part of the student for their own learning. The performance on the semester examination revealed that the students were capable of devising their own questions. The testing situation of the semester examination, however, forced the students to do so. I did not consider this an increase in responsibility because, at this school, the semester examination was an extremely important grade.

Students will not ask questions unless they are curious and amenable to relearning the learning processes, no matter what must be torn down. They also will not ask questions unless I influence them properly. This was shown by the results of the second period class in which I gave hints, as compared to the results of the next class, in which I did not influence the formation of questions. The first class wanted their questions to be close to the question I had conceived, whereas the latter class came up with many creative questions. The students actions are directly related to the teacher's actions.

The technique that I used for increasing students' responsibility for their own learning collided head on with the patterns established through years of schooling. Change does not come quickly or easily.

"The technique that I used for increasing responsibility for one's own learning collided head on with all of the patterns established through years of schooling."

Postscript

I modified my classes for the second semester. Instead of presenting the students with materials and a challenge to create their own questions and solutions, I presented them with a general area of study and asked them to choose a way to learn about the area and present it to the class. I allowed the students to continue working in groups.

This generated more enthusiasm, creativity, and diligence than any of the first semester investigations. For example, when we studied simple machines, one group that had not been particularly interested in the investigative process created a song about simple machines and sang it to the class! Also, the students turned our study of complex machines into projects to assemble three or more simple machines into complex machines.

As the end of the school year approached, I gave the students the freedom to investigate any subject in the book that we had not discussed. The students were overjoyed! They chose to study minerals, the cell, animals, drug reactions, the ocean, the

plasma state of matter, eating disorders, a comparison of the human eye and cow eye, and dissection of a frog and a fish. Their investigations included a list of questions, two laboratory procedures of their own creation, a two-page report summarizing what they had learned, and a class presentation. Every group worked diligently and every student was enthusiastic, except Tom. Tom just attached himself to a group and did what they assigned to him.

Many things that happened during this time were very exciting and encouraging to me because they showed that my students had begun to accept responsibility for their own learning. For example, one student, at the completion of the cow eye lab, announced that he no longer wanted to be an athlete. He now wanted to be a doctor!

Another was that Kay became a leader in her group. She helped the group organize their lab activities, and even came in after school to learn to use the computer to type up the reports and papers. This group compared the speed of the flow of blood in a goldfish's tail before and after exposure to caffeine. When they completed this experiment, they were so proud of themselves that they created another experiment which compared the sense of smell in males and females. Kay's group's presentation was one of the most organized and interesting presentations we heard.

Furthermore, Lori demonstrated much more responsibility. Lori worked independently on a project of her own invention which involved her pets. Her parents would not bring her pets to school for her presentation, but Lori, who previously required much parental support, did a wonderful job of thoroughly explaining her project to the class without her pets.

If I were to repeat this study I would allow more freedom of choice around the third or fourth week of school. Without a doubt, the students needed to acquire the essential skills I taught during the first semester, such as writing a procedure, recording results, and graphing. Yet it seemed that, when I finally gave the children the freedom to select their area of study, they also felt free to ask and answer their own questions, and they started to accept the responsibility for acquiring their own knowledge.

I would also emphasize more strongly that what they wanted to learn was more important than what I thought they should learn. At last they stopped asking me what I wanted them to know and began asking themselves what they wanted to know. Thus, I would try to be more of a facilitator than a direction giver in class.

By the end of the year I was encouraged. I realized it is difficult for both me and the students to change methods and incorporate new ways of becoming responsible for learning. ❖

Epilogue

by Jane B. McDonald, Editor

Ms. Haydon truly has the heart of a teacher. She builds rapport with her students, adapts her styles to meet the students' needs, and experiments with new

"They had at last stopped asking me what I wanted them to know, and had begun asking themselves what they wanted to know."

ideas. She says she teaches the way she does because it is more fun for her and her students, even though it is more work.

Ms. Haydon's twenty-six years of experience include a variety of teaching situations—public, private, high school, middle school, and elementary. This action research was conducted during the only year she taught at a university developmental school. She is currently teaching seventh and eighth grade integrated science in a rural K-8 public school. Implementing a radically different teaching style in a new situation was very risky and threatened the confidence of even an experienced teacher such as Ms. Haydon.

Ms. Haydon's enthusiasm for her action research project turned to anxiety early in the semester: "It was exciting to start a new

Toni B. Haydon

Years Teaching: 26

Present Position: 8th grade Integrated Science Teacher

Children need to learn how to become learners. No one will teach them as we do in schools during the rest of their lives. If they want to become educated they must do it for themselves.

Action research is a method of self-analysis for a teacher. When other people critique you, you can attribute their comments to a difference in teaching styles. But action research, and videotaping in particular, helps you take stock of what really goes on in your classroom, and to change, or to stay the same. Make sure you do not try action research at a new job, because the pressures of establishing yourself are great enough.

project and be involved in research. But a month into it I thought, 'This is ridiculous!' The kids would just sit and not do anything. I thought I was wasting the kids' time. My principal kept coming in and watching me. Everyone said, 'What are you doing in there?' But as we continued into the next semester, the kids blossomed. They became really interested in science and went wild when I gave them the opportunity to research whatever they wanted to research. We had eleven different projects going at one time! In retrospect, it was very worthwhile." As further evidence of this, Amy, who had lacked confidence in her own ability, went on the following year to win third place in the State Science Fair.

Ms. Haydon's situation illustrates the need for teachers to communicate. Although Ms. Haydon was very creative on her own, she was fairly isolated from other science educators while teaching for seven years in a private school, and she was definitely not in the loop for hearing about workshops, conferences, or "how-I-do-it" chit chat. Her participation in Science FEAT, in fact, was serendipitous. As she began the Science FEAT program, she was very quiet because she was not used to sharing ideas. Science FEAT provided contact with other science educators and gave her the opportunity to share experiences, participate and speak in front of groups, and take classes. Ms. Haydon gained not only new ideas but confidence from her participation in Science FEAT.

Ms. Haydon has joined the "network," now. She informally shares her action research with other teachers. Educators from a variety of levels and disciplines, such as biology, history, ESE[2], and college chemistry, have all tried variations of her idea of letting the students ask and answer their own questions. She herself continually adapts her methods to her situations as she strives to help students "learn how to learn."

Jane B. McDonald

Reference

Schank, R. (1988). *The creative attitude.* New York, NY: Macmillan Publishing Company.

Footnotes

1 All names are fictitious.
2 Exceptional Student Education (ESE).

CHAPTER FIVE

So You Want to Do Action Research?

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This chapter is reproduced with permission of the publisher and authors from a previously published monograph entitled *Action Research: Perspectives from Teachers' Classrooms*, which contains edited reports of action research conducted by middle school classroom teachers who participated in the Science FEAT Program.

If, after reading about classroom-based action research by science teachers, you think this is something you want to do in your classroom or school, this chapter is for you. It is organized into three sections. The first, a definition of action research, briefly traces the evolution of the concept of action research. This section is presented in a rather formal style. The second section presents some guidelines for doing action research. The third, using statements from the Science FEAT teachers who did research and from their administrators, provides advice. If you want to learn *about* action research, read the sections in the order presented; if you want to *do* action research, read the sections in reverse order.

A Definition of Action Research

Action research currently is an important genre in the field of education. However, it is a genre that has and continues to evolve. Kurt Lewin (1946), a social scientist concerned with major social problems of the period, is credited with coining the term *action research* in the years after the Second World War. He argued that through action research advances in theory and needed social changes might be simultaneously achieved. Lewin described action research as a spiral of circles of research that each begin with a description of what is occurring in the "field of action" followed by an action plan. The movement from the field of action to the action plan requires discussion, negotiation, exploration of opportunities, assessment of possibilities, and examination of constraints. The action plan is followed by an action step which is continuously monitored. Learning, discussing, reflecting, understanding, rethinking, and replanning occur during the action and monitoring. The final arc in the circle of research is an evaluation of the effect of the plan and action on the field of action. This evaluation in turn leads to a new action plan and the cycle of research begins anew. The value of action research in educational situations was almost immediately apparent. Through his book, *Action Research to Improve School Practice* (1953), Stephen Corey at Teacher's College, Columbia University, was influential in introducing action research into mainstream education.

Robert Rapoport (1970), still focusing on general social problems, added an element of ethics to the definition of action research

when he claimed that it "aims to contribute to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework" (Rapoport as cited in Hopkins, 1993, p. 44). In 1983, Stephen Kemmis defined action research as:

> *a form of self-reflective enquiry undertaken by participants in a social (including educational) situation in order to improve the rationality and justice of (a) their own social or educational practices, (b) their understanding of these practices, and (c) the situations in which practices are carried out (Kemmis as cited in Hopkins, 1993, p. 44)*

By this time, the place of action research in education was clear. With the inclusion of a focus on justice, the current close relation between action research and critical theory was introduced. In 1985, Dave Ebbutt solidified the role of action research in education when he stated that it "is about the systematic study of educational practice by groups of participants by means of their own practical actions and by means of their own reflection upon the effects of these actions" (Ebbutt as cited in Hopkins, 1993, p. 45). Ebbutt quotes Kemmis when he continues that "Action research is trying out an idea in practice with a view to improving or changing something, trying to have a real effect on the situation" (Ebbutt as cited in Hopkins, 1993, p. 45). John Elliott (1991) states that action research aims to feed practical judgment in concrete situations, and the validity of the 'theories' or hypotheses it generates depends not so much on 'scientific' tests of truth as on their usefulness in helping people to act more intelligently and skilfully (sic). In action research, 'theories' are not validated independently and then applied to practice. They are validated through practice (p. 69).

It is not surprising that, in the fifty years since Lewin introduced the idea of action research, the genre has developed and changed. Action research is seen to complement and blend with other modes of inquiry. For example, Lawrence Stenhouse (1975) pointed out that action research and the idea of teacher as researcher, an idea he introduced as a way to improve education through empowering teachers by engaging them in curriculum development, were closely related. Also, as disciples of action research developed, implemented, and refined models of this mode of inquiry, terms were created to distinguish variations of the method. In his book on action research for teachers, which he terms classroom research, David Hopkins (1993) describes at least four variations of action research. All models include cycles in which a situation exists (a field of action) where a practitioner desires to make a change, an action plan, an action, and an evaluation. All variations of action research described by Hopkins require reflection.

Possibly Virginia Richardson (1994) best captures the spirit of this form of research when she says that practical inquiry, a term for one variation of action research, "is conducted by practitioners to help them understand their contexts, practices and, in the case of teachers, their students. The outcome of the inquiry may be a change in practice or it may be an enhanced understanding." Whether it is termed action research, classroom research, or practical inquiry, the genre formalizes an aspect of teaching that expert teachers have known about and employed for a long time. They observe situations in their classrooms that are less than optimal, they identify the problem, they think about what and how to change, they make the change, they evaluate the impact of the change on the situation and begin again.

A Description of Action Research

Identifying a Problem

In education, the classroom and the school provide the situation, using Lewin's term for context or setting, for action research. As described in this monograph, action research begins with thoughtful reflection on classroom practice. This thoughtful reflection might be initiated by an observation by one teacher of another teacher's classroom practice, by a conversation with a colleague, by viewing and reviewing a videotape of some lessons, by a student question or behavior, or by a parent comment. Alternatively, the thoughtful reflection might be triggered by reading a book or attending a course or seminar on science teaching and student learning. An outsider cannot tell a teacher what is the appropriate action research for her classroom. Action research in classrooms must be teacher initiated.

Observation and reflection help identify a problem. In daily use the term problem describes a situation in which something is wrong, something needs to be corrected. In action research the term problem describes the focus of interest. Often the problem is something that, while it is quite all right, the teacher judges is less than optimal. The teacher might wonder if student achievement could improve if she tried a new instructional strategy. Student achievement was not bad, but could be improved. Sometimes in action research the problem is termed the purpose, the topic, or the issue, to avoid the negative connotations associated with the word problem. In choosing a problem, a teacher needs to be sure there is a close relationship between the problem and the proposed change. Further, the problem needs to be something that is within the teacher's power to change. While changing the school's budget might improve student achievement, teachers today rarely have the authority to make budget changes. Even if a teacher had budget authority, she would need to make a strong case for the relationship between budget and student achievement if these were the two concerns in her action research.

Making a Plan

The next step in action research is to plan the action. The plan needs to conform to some existing method of research and to rely on good research tools. If the teacher chooses to survey students' opinions, the survey must be constructed properly. The wise action researcher begins by looking for existing tools that meet the needs of the research, or that can easily be modified to meet those needs before trying to construct original research tools. If a teacher chooses to do interpretive research such as a case study, she must adhere to the guidelines of interpretive research. For example, if a teacher is doing a case study, she must define the system that is being studied and its boundaries. She must plan to collect information about the system and search that information for patterns that are meaningful to the problem being researched. She must plan to return again and again to the system to look for confirmations, exceptions, and variations of the patterns that are emerging. If a teacher chooses an interpretive research method, the tools of interpretive research must be employed. A prime tool of interpretive research is triangulation. Triangulation requires that the situation in which the change is being made is examined multiple times in multiple ways. A teacher might triangulate by gathering the same information from a number of students on different occasions, several weeks apart. A teacher might plan to triangulate by collecting information in different ways such as from interviews, from observations, and from test scores. A teacher might triangulate by getting information from

different people in the situation such as students, administrators, and parents. Books on research methods such as *Complementary Methods for Research in Education* (Jaeger, 1988) provide a good primer for planning educational research.

When doing an action research plan, the more a teacher can anticipate the action, the more detail she can include in the plan. The more detail in the plan, the less likely the teacher will have to make instantaneous decisions without the benefit of reflection. In planning action research a teacher might ask: Which class or classes shall I study? Which student or students? What types of information will I collect–paper, audiotape, videotape? How frequently will I collect information? What is the duration of each data collection activity? What is the duration of the study? How will I keep all the information I collect stored and organized? If I am keeping a journal myself, what will I give up to make time to write in my journal? Doing an action research plan requires reflection.

Taking Action

Having made a plan, the teacher begins the action research. Even the best plan will be modified as the research continues. There will be unanticipated events that must be accommodated. As information is collected and patterns begin to emerge, different information than what had been anticipated in the plan may be necessary. During the action phase of action research, a teacher must make time to carefully examine the information that is being collected. This careful examination is both analysis and reflection. As the information is organized and examined in relation to the original problem, the raw, unexamined information becomes data to support assertions about the effect of the changes in the classroom. An assertion is a statement that expresses what has to be learned through the action research. The masterful action researcher will have included the data analysis procedures in the plan. While the circumstances of the action may change the planned analysis, it is a real predicament to have carefully gathered extensive classroom data and not have any idea what to do with it.

Evaluating the Effect of the Action

As the action period comes to an end, it is time for evaluation and more reflection. Questions that a teacher might ask to stimulate evaluation include: What impact has this change had on my students? On their learning? What have I learned about students? About learning? About the subject matter, in this case science? Should this change become a regular feature in my classroom? How can I make this change a regular feature? Is it cost effective? What new problems have emerged that I now want to research?

Communicating about Action Research

Action research by classroom teachers includes the need to communicate with others about the research. This requirement comes from fundamental beliefs that both teaching and research are activities that occur in communities, and that valued knowledge in those communities must be public. In order for knowledge to be public, it must be shared. Some use the term persuade to describe the manner of sharing that is part of action research. It is more than just telling; it is not telling a story and it is not telling everything. It is telling the important points in a manner that is lucid, concise, explicit, and in a way that shows a logical relationship between the problem, the action, the information collected and analyzed, and the evaluation of the action on the situation. This public sharing of action research is not easy. In order to articulate their ideas, teachers need to think critically and systematically about their practice. While national reform movements in education such as the National

Board for Professional Teaching Standards (1991), and leaders in education reform such as Shulman (1987) make it clear that teachers need to be able to articulate their professional knowledge, sharing ideas about teaching (other than recipe swapping such as "have you tried this") has not been part of the common practice of teaching. Further, the skill of sharing substantive ideas about teaching generally has not been taught in teacher education programs.

Whether writing or talking, deciding what to say and how to say it requires effort. The teacher as action researcher must decide how much to say about the original situation—the classroom. Other decisions involve how much to say about the research plan (including when it was followed, when the research deviated from the plan, and why), what information was collected, how the information was analyzed, what new insights were gained during the action research, what new understanding the teacher has achieved, what changes the teacher will make in her practices, and what recommendations she might make to others in a similar situation. All of this knowledge must be shared in a clear, precise manner. And it must be pleasing and interesting to read or hear.

More and more frequently, teacher researchers have opportunities to share their research publicly. The journal *Teaching and Change* only publishes research by teachers. Even as this monograph is being prepared, other journals about research and science teaching such as *Science Education* and *Science Scope* are considering regular sections that include classroom research by teachers. The annual meetings of national and regional organizations of science teachers—such as the National Science Teachers Association, the Florida Association of Science Teachers, and the Florida Educational Technology Conference—provide teachers opportunities to share their research. Teachers also have opportunities to share research through workshops and local research activities.

Maintaining Collegiality

If it were possible to publish the next sentence in flashing neon lights, that still would not be sufficient to highlight its importance. *Action research cannot be done in isolation.* While research is a solitary activity and reflection done by oneself is an essential component of action research, teachers, or anyone else for that matter, cannot successfully engage in action research without support. This support comes from others—teachers and teacher educators—who have or are engaged in action research. This support is in the form of opportunities to discuss the problem situation, the action plan, the analysis, and the communication in a critical but non-judgmental environment.

Teachers engaged in action research also need support from administrators who recognize that it is demanding. Different schools will need to work out different forms of support. Reduction in committee work, an additional aid, or the use of in-service time for research are some possibilities. Schools in which teachers, with the support of their administrators, are engaged together in action research within the classrooms and across the whole school are moving toward the vision of the school as a community described recently in the National Science Education Standards (National Research Council, 1994).

While it is relatively easy to describe the phases of action research in sections in a paper, in practice the distinctions of the phases blur and overlap. The variety of topics, methods, approaches, and presentations in this monograph reflect only some of the variations in action research by classroom teachers.

Some Advice on Doing Action Research

Teaching is a demanding and complex activity. Doing research also is a demanding and complex activity. The melding of the knowledge and skill of both teaching and research required to conduct action research in a classroom situation can be daunting in the demands and complexity presented. It seems that some advice from those who engage in action research would be useful to classroom teachers who are considering an action research project. This section will share advice from three points of view: a university-based instructor who works with teachers engaged in action research, the classroom science teachers who have just completed an action research study, and some administrators of schools where action research has occurred.

Advice from the University

David Hopkins published his first edition of *A Teacher's Guide to Classroom Research* in 1985. At that time he had been working on projects that engaged classroom teachers in Canada and the United Kingdom in action research for almost ten years. The second edition of his book, *A Teacher's Guide to Classroom Research—Second Edition* (1993), reflects insights from additional years of experience. For those interested in conducting action research, the book is well worth reading. In Chapter 4, he presents six criteria for classroom research by teachers. These criteria provide some good advice to action researchers.

Teaching. Hopkins reminds readers that a teacher's first responsibility is to teach. Any research should not interfere with or disrupt this primary responsibility. With this advice he includes an ethical dilemma about teaching. If a teacher is trying a new instructional strategy for the first time, her presentation is likely to be ragged. Is a teacher remiss in her responsibilities if she replaces an adequate instructional strategy with one in which her performance may be less than adequate? Or is she remiss if she does not attempt new strategies which may eventually improve student learning? He resolves the dilemma by relying on the professional judgment of the teacher. If the teacher is so committed to improving teaching and learning that she is willing to engage in the rigor of action research, those outside this classroom must rely on her judgment to do nothing that will harm students.

Time. Hopkins' second criterion is that the method of data collection cannot demand too much of a teacher's time. This implies that the teacher needs to be certain of the details of the data collection method before she begins. For example, if a teacher chooses to audiotape classroom discussion, she needs to be aware that it takes about twice as long to listen to a tape as to make it and about four times as long to transcribe it. The teacher engaged in action research needs to plan and use efficient data gathering techniques and a reasonable data gathering and analysis timetable. Here, administrators can provide some time to a teacher engaged in action research by such support as a reduction in extracurricular responsibilities.

Method. The method of data gathering needs to be sufficiently reliable that the teacher is able to formulate hypotheses and/or assertions with confidence. The teacher must have sufficient confidence in the research method that changes in classroom practice based on information from the method can be undertaken without undue concern.

Problem. The teacher engaged in action research must be committed to the research problem. It seems self-evident to state that it is difficult, if not impossible, to sustain the energy required to engage in research on a

problem if the concern is not real and personal. Further, the problem needs to be definable and solvable. As Hopkins says, dealing with amorphous and overly complex problems that have no solutions only leads to frustration.

Community. In so far as possible, engaging in action research to improve teaching and learning should take place in the context of a school community that shares a common vision.

Ethics. Doing action research presupposes ethical behavior. Hopkins relies on the ethical guidelines for action research presented by Kemmis and McTaggart (1988). Some of these ethical guidelines that impact classroom research include:

- Observe protocol. Make sure that all relevant persons are informed and all necessary permissions and authorizations are obtained. For example, permission might be required to videotape students, to use student work samples, or to audiotape interviews. Obtain explicit permission before using direct quotes.

- Confidentiality. Accept the responsibility to maintain confidentiality and act accordingly. For example, use pseudonyms in place of actual names.

- Negotiate with those affected. Consider the wishes and responsibilities of others who are in the situation where the action research will occur. This might include the students, other teachers of the same students, administrators, or parents. Allow others whose work you describe to challenge your interpretations. Allow those involved in meetings and interviews to add to or edit their original statements. Such practices increase fairness, accuracy, and relevance.

- Report progress. Keep the work visible and share expected and unexpected outcomes or insights with others interested in the problem.

- Make your principles binding and known. While the researcher wants to encourage others who have a stake in the outcome of the action research to get involved, all people engaged in action research must agree to the principles before the work begins; all must understand their rights and responsibilities in the research process.

Advice from Classroom Teachers

Each of the Science FEAT teachers engaged in action research during the 1994-1995 academic year was asked to put in writing some advice to another teacher who might be considering an action research project. The advice they gave is not substantively different from the advice of the university-based action researcher, but it is captured in the words of the classroom teachers. Their advice is a product of their experience and comes from the heart. It is not easy to capture in typeface the emotion presented in oversized letters, different colored inks and multiple exclamation points. The following section, organized by themes, weaves together the direct quotations from the Science FEAT teachers. The themes which emerged from reading and organizing the advice are research: choosing your topic; designing your research; conducting your research; communicating your research; gaining support; and surviving. These themes are addressed in the teachers' own words.

Choosing your topic. Think a lot about your research topic. Do something that is relevant and meaningful to you personally. Choose a subject you are very interested in exploring, or a question you have a burning desire to answer. Make it relevant for you. It is really important to do research on a topic that

interests you, something that you have been curious about. You will find yourself "married" to your research, so that choosing a subject you really want to "spend time with" makes the union easier and more enjoyable.

Identify a question that you would like to investigate about your teaching style, methods, or classroom environment. Focus on your classroom and students. Choose a topic that will have force in the way you teach and the way students learn. For the research to be useful to you it needs to be something that will improve your teaching and something that will have meaning for your particular situation. Choose a topic that will be personally beneficial for you to explore. Choose a topic that will help you to become better in your profession. All that hard work will then be worthwhile. Consider your individual interest, time required, participants.

Spend lots of time narrowing your choice of topic down because you will spend lots of time with it. Keep it narrow. Narrow it down to one or two things. The narrower the better. The narrower the subject the easier it will be. It doesn't have to be something too involved. Try to limit the scope of the research. The project tends to grow and become more and more complex. Make sure you have focused or zeroed in on your actual question before you begin the study. Otherwise you will have trouble narrowing your search and wind up with too much irrelevant data.

Keep it simple. Keep it simple. Keep it simple. Keep it simple. Keep it simple and precise. Keep it direct and simple. Simple is not bad. Think small. Don't try to answer more than one question and try to make your question as basic and measurable as possible. Design your study so that you are concentrating on one facet of your problem. Stick to one variable. You will discover many other questions that concern your topic—you need to stick to one. Don't bite off more than you can chew.

Observe videotape footage of yourself engaged in teaching to identify aspects of teaching which could benefit from being the focus of research. Make some journal entries after every day of teaching and audiotape or videotape two or three lessons to look for strengths and weaknesses. Read research done by other teachers. Read recent research literature to find out what others are thinking. Read as much literature as possible. Put sufficient time into planning functions. During this phase research is the key. This must include more than library research; talk to others who have done it, to experts in the field, seek community help.

Designing your research. Carefully plan the data collection process. Define data collection and analysis clearly from the outset and solicit one or more people to assist you in data collection. I did this and it was extremely helpful. Be sure that the methods used to study the question match the purpose of the study. Make a trial run beforehand. After my first attempt this year it would be much easier to do again.

Conducting your research. Jump In! If there is an area in your classroom you'd like to investigate, a technique you'd like to try, or something you wonder about in your teaching practice, think about how you might investigate your question and start. Don't put off getting started. Just as soon as you know what your question is, start planning to collect your data. Start early in the school year to be sure there is plenty of time to update and follow up on the results you may get. Continue the research for a long enough time to be able to draw some conclusions.

Make sure you are clear in your own mind about the data collection: keep a notebook with you at all times to jot down notes about

classroom occurrences. Collect feedback from students—it can be formal or informal; if data about attitudes is being collected, use some videotapes—body language is important. Prepare well in advance. Make sure you have all the necessary materials. Organize your materials so they are readily accessible. Have all your equipment ready and working when videotaping and audiotaping. If videotaping your classroom, I found it more useful when someone came in to run the camera. When the camera was just mounted on a tripod, much of the class action was lost. On any survey or interview include as a final comment, "Any other comments, observations, questions and suggestions?"

Don't be surprised if your research takes several turns and twists before completion. Look for the unexpected. Be flexible. Be prepared to reflect frequently on how the research is going. Don't feel that you must remain true to your original statement. If data or experience lead you in a new direction, give serious consideration to following it. Accept the fact that your research may change (your method or your focus) once you have begun. You may find that certain constraints dictate this. You may find that your data causes you to look at your question in another way. Certain aspects of your study may be better 'dropped' since they offer no insight into your revised focus. [But] after you have reached your research question and completed gathering your data, if you find new data don't try to add it after your paper is complete or you will work yourself to death. I did this and it was extremely hard (no matter how good the information is).

Organize! Organize your personal life. Time will be short. Spend a few extra minutes getting organized. Get a box and keep all research documents together. Have a special container on hand (a bin, a folder, a file drawer) to drop student work in. Set up a special file cabinet drawer to keep all of the material you collect. Prelabel your folders. Have one for method, data, student work, journals, literature, etc. Review data frequently and label it clearly. Be careful to keep your notes together. I used several legal pads scattered around my classroom. If I had used one, it would have been easier to compile notes in my journal.

Analyze data as you get it, record it as you go. Only analyze the data you need. Work with a small sample of students to keep the work manageable. Develop a timeframe to follow and then maintain it. Always write down everything. Regardless of the type of research, a journal is of great use in recalling what happened. Make one. Keep a journal. The journal should be written in every day. If not, you will forget some very important insights and events that may be important to your final paper. The journal will not only help you on your paper, but help you realize your own personal growth as you learn from your research. Your progress and change will be more evident to you.

Communicating your research. Be sure to have someone review your work, especially someone with a 'scientific' mind and an English background. If you can't find one person with both strengths, you will need to have two people. One must read for content and the other for grammar. Find a slash-and-burn editor. You will be so emotionally tied to your writing and the story behind the words that you cannot be objective. You don't need a "friend" who is afraid to say "I didn't understand what this part is doing here," or "Your sentences are too wordy." Find someone who has both the competence and the assertiveness to really edit your paper. Don't take the criticism personally. And if the suggestions for change alter your fundamental feel for the writing, don't make them.

Do not extend the writing phase too much or you will lose your focus.

Keep updated versions of your paper on the hard drive and 2 or 3 disks.

Gaining support. Administrators should be briefed on the facts of the process and understand thoroughly how much is involved in the preparation of a quality project. They should put in writing that they are aware of it so they can be reminded when it slips their mind. It takes a lot of time and effort to do research in a classroom. Gain support from the administration so that the obligations outside the classroom are severely limited. This should include not teaching new subject matter. Do not take on new teaching assignments when beginning to do research. It would be valuable to have a lighter teaching schedule, due to the amount of time needed to do research. Don't volunteer for extracurricular activities.

Talking to others helps even if they are not doing research. Share your research with colleagues and mentors. Their suggestions and opinions can be valuable. Review data the first time in the presence of a supportive partner. Pace yourself and take advantage of the assistance being offered.

Surviving. Remember to consider the workload demands of conducting classroom research when doing your classroom planning. Use your free time and planning time well. Don't take on any other outside tasks—avoid serving on school committees, taking that office at church, or anything that you can defer until later on. Your study will take up more of your time (and even your emotional energies) than you think. During the research time it is hard to find the life outside of teaching and research. Remember family and friends.

Go easy on yourself, if you see flaws in your practice. Don't get discouraged. Get lots of input but trust yourself. This is your personal journey. If it doesn't fit someone else's vision of what 'research' is, fine. But it's your journey and you are the only one who knows what you are seeking. Enjoy the experience!

Advice from School Administrators

The administrators of the schools in which the Science FEAT teachers work were invited to make recommendations to other administrators at schools where teachers are considering action research. While not as extensive as the teachers' advice, it is powerful.

An administrator needs to celebrate what a teacher has done. Be tuned into teachers that seem to be asking questions and suggest they get together with another teacher who has done action research. For teachers who want to try it out, use action research as the teacher assessment tool instead of the traditional form.

Administrators must provide resources to teachers who show promise through action research. Allow the teacher the freedom to explore and the time to implement action research. Expecting them to grow without providing enough resources is ludicrous. Provide additional planning time. Provide more teacher assistant help. Allow flexible curriculum.

A Very Personal Conclusion

I have been privileged to work with the teachers participating in the Science FEAT Program since its inception. I have worked with them as they learned research methods, as they developed the action research plan, as they initiated and followed the plan, as they analyzed the data, as they evaluated their classroom practice, and as they prepared written papers. I have watched and listened as they have formally shared teacher initiated and designed, classroom-based action re-

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Years Teaching: 28

Present Position: Associate Professor of Science Education, Vanderbilt University

Awards & Accomplishments:
Alumni Achievement Award, University of Wisconsin, School of Education, 1996
Innovation in Teaching Science Teachers Award, Association for the Education of Teachers in Science, 1995
Director National Science Education Standards, 1994-1995
Principal Investigator Science FEAT, 1993-1995
Fellowship AAAS, 1994

Action research is valuable for I feel it provides teachers one structure for professional growth.

Samuel A. Spiegel

Years Teaching: 8

Present Position: Director of K-12 Educational Programs, National High Magnetic Field Laboratory, Florida State University

Awards & Accomplishments:
Innovation in Teaching Science Teachers Award, Association for the Education of Teachers in Science, 1995
Program Director of Science FEAT, 1993-1995

My involvement with the Science FEAT program has been truly educational and rewarding. Some of the most rewarding moments have been when I have had opportunities to work in small groups or one on one with the teachers and their students.

Research is a difficult yet worthwhile endeavor. Action research presents a potential tool for teachers to focus on enhancing their classrooms. It allows them to enhance education by focusing on the problems, constraints, and solutions within the local contexts of their schools.

search with one another in a university-based colloquium. While many experiences with these teachers doing action research bring me joy and hope, allow me to close by sharing one. Daily a Science FEAT teacher will say to me something like, "I know so much more about classroom research, next year I am going to redo my study but just focus on. . .," or "I have so many more questions now than I did last summer, I am not sure which one to research next year," or "My study for next year is already set; I plan to. . .". With teachers with such knowledge, skill, and dedication, I am confident that the future of science education is in good hands.

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